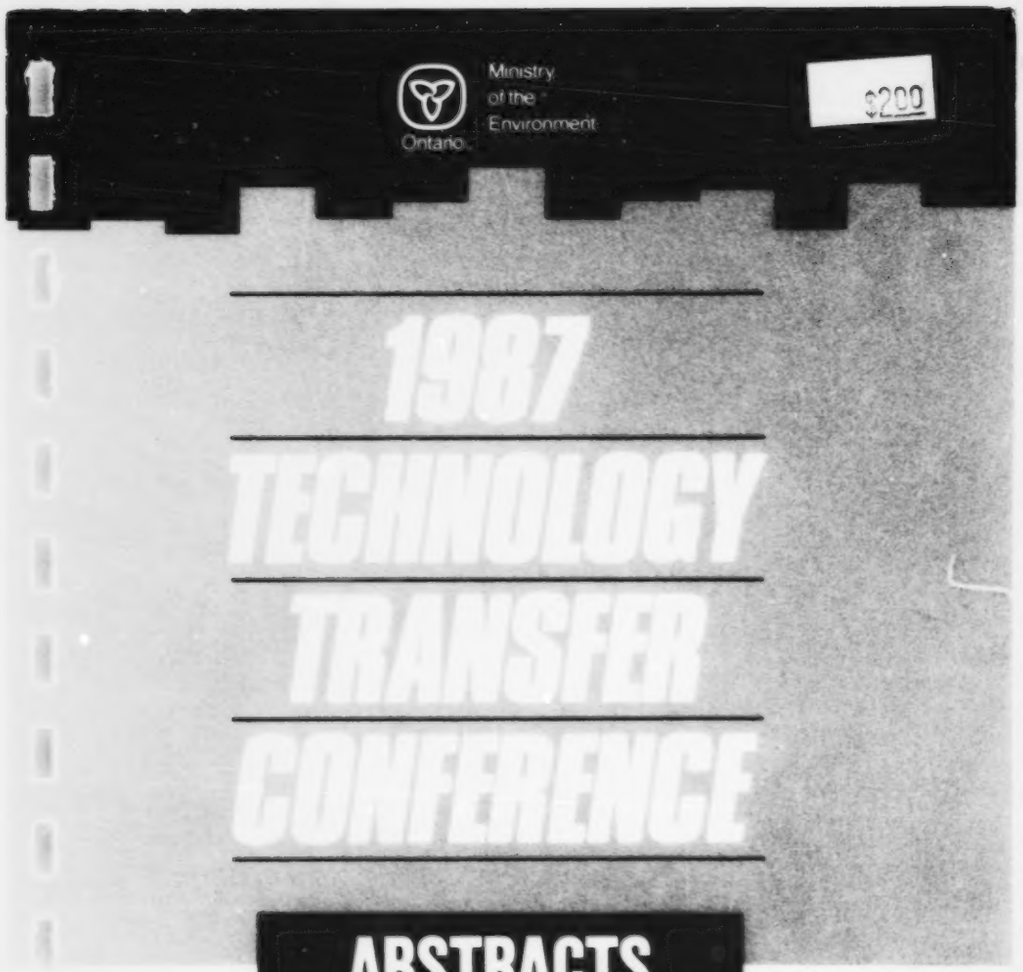

ABSTRACTS

NOVEMBER 30 &
DECEMBER 1, 1987

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TORONTO, ONTARIO, CANADA

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ABSTRACTS

TECHNOLOGY TRANSFER CONFERENCE

November 30 - December 1, 1987

Royal York Hotel

INTRODUCTION

Environment Ontario holds its annual Technology Transfer Conference to report and publicize the progress made on Ministry funded environmental and health related research projects. These studies are carried out in Ontario universities and private research organizations.

This booklet presents the abstracts of the papers presented at the Technology Transfer Conference, held November 30 and December 1, 1987. The abstracts are divided into five sections, corresponding to the conference sessions dealing with air quality research, water quality research, liquid and solid waste research, analytical methods and instrument development as well as environmental economics.

For further information on any of the projects, the reader is kindly referred to the Conference Proceedings, or to the principal investigators. Abstracts for oral papers (A1, A2...) are followed by abstracts for poster presentations (AP1, AP2...) for each session. Abstracts for feature and keynote papers are not included in this booklet.

DISCLAIMER

The views and ideas expressed in these papers are those of the authors and do not necessarily reflect the views and policies of Environment Ontario, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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A1

BIOLOGICAL AND CHEMICAL TESTING OF COKE OVEN EMISSIONS.

N. Belson, A. Horton, K. Shaw & G. Thomas*

This study represents part of a program the overall objective of which is to help establish a practical ambient air standard for PAH based on their mutagenic potential. The coupling of short term biological tests with chemical analysis techniques is a rapidly evolving field for use in environmental health assessment.

In order to obtain large amounts of PAH for experimental work, sampling was conducted at coke oven sites. In Phase I soluble organic fraction (SOF) extracts were obtained from Hi-Vol filters and back-up polyurethane foam (PUF) for samples collected from coke oven lids and top side ambient locations. These SOF were subjected to tiered biological testing (Ames and SCE-CHO) and semi-quantitative chemical analysis.

In Phase II which is reported here, selected SOFs have been subjected to a fractionation scheme in which the complex mixtures were separated into carefully defined chemical fractions. The reason for this was in order to better isolate the mutagenicity and better define the chemistry both qualitatively (identification) and quantitatively.

This paper will present the results obtained, firstly, in terms of biological testing with respect to dose response data for the separated fractions and calculations of specific activity (Rev/µg) and mutagen density (Rev/m^3). Secondly, in terms of chemical data with respect to identification of individual chemicals and their concentration within each fraction.

A2

HEALTH EFFECTS ON ASTHMATICS OF DAILY VARIATIONS IN EXPOSURE TO PARTICULATE MATTER. Frances Silverman,* Paul Corey, Anthony Ayiomamitis and H. Roland Hosein, Departments of Medicine and Preventive Medicine and Biostatistics, University of Toronto.

The health risk of low level air pollution exposure is still uncertain. Vertical and horizontal differences in air pollution exist and outdoor air differs substantially from indoor air. Thus levels of air pollution measured at fixed outdoor sites may not reflect levels actually inhaled by an individual, i.e. "personal exposure". Effects documented using severe response variables tend to ignore minor fluctuations in disease, e.g. asthma.

In this study exposure was assessed by both personal monitoring and at a fixed air pollution monitoring site in downtown Toronto, to examine the relative strengths of the two estimates of exposure as demonstrated by their association with measures of health effects (pulmonary function). Small multipollutant samplers for nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter were carried by volunteer asthmatic subjects (P) and simultaneously a sampler of the same design operated at a downtown Toronto air pollution monitoring station (GMOE). Subjects were each tested on up to 20 days in both summer (n=10) and winter (n=10); pulmonary function (spirometry) was assessed at the beginning and end of each monitoring day.

A longitudinal analysis, within individuals, of the relationship between pulmonary function and particulate matter, revealed a season effect when the personal exposure monitoring data were used (P). This was not observed when the exposure data from the fixed site (GMOE) were used in the analysis. Using a cross-sectional analysis correlating mean pulmonary function with mean particulate exposure, there was no significant correlation using either P or GMOE monitoring.

We conclude that assessments of personal exposure and season of the year as well as study design and methods of data analysis (cross-sectional vs longitudinal) are important factors in determining health effects of air pollution.

A3

ASSESSMENT OF TOXICITY OF INGESTED AND INHALED HALOAROMATIC HYDROCARBONS.

David A. Clark & George D. Sweeney, Department of Medicine, McMaster University, Hamilton

The effects of environmental exposure to a variety of haloaromatic hydrocarbons remains uncertain. Frequently, mixtures of different compounds are involved. We have tested the effects of purified haloaromatic hydrocarbons on the immune system of laboratory mice with particular emphasis on the generation of immune killer T cells (CTL). Weekly injection of 2,3,7,8-TCDD has been shown to impair CTL generation at a cumulative dose of 12 pm, and the mechanism of impairment has been attributed to a direct effect on epithelial cells in the thymus gland that promote the production of regulatory suppressor T cells. Aroclor 1254 and 3,4,3',4'-TCB that can interact with the cellular receptor to TCDD could also produce suppression. We have extended these studies to other halogenerated dibenzodioxins and debenzofurans. 2,3,7,8-TCDF proved as active as 2,3,7,8-TCDD, but addition of a Cl at the 4 position (2,3,4,7,8-PCDF) reduced potency by a factor of 1000. A Cl at the 1 position of TCDD (i.e. 1,2,3,7,8-PCDD) reduced potency by a factor of 10,000. The toxicity of 2,3,6,7,8- and 1,2,3,4,7,8-HCDD was also less than 2,3,7,8-TCDD.

Since inhaled particles are trapped in mucus and swallowed, oral feeding of haloaromatic hydrocarbons offers a feasible approach to the assessment of potential toxicity of both contaminated food and smoke. Suppression with oral 2,3,7, 8-TCDD was more variable and could be localized to either spleen or lymph nodes. In one experiment, there was complete resistance to suppression up to 12 nm dose. To distinguish between failure of absorbtion and differences in production and localization of suppressor T cells from thymus of untreated animals, induction of mixed function oxidases in the liver is currently being assessed in mice fed TCDD and related haloaromatic compounds.

A4

DIRECT MEASUREMENTS OF GENETIC MUTATION AND ABERRATION RATES IN PULMONARY CELLS. J.A. Heddle,* A. Bouch and D.B. Couch, Department of Biology, York University, Toronto, Ontario, M3J 1P3.

Although lung cancer is one of the potential hazards from air pollutants, it is not practical to use cancer bioassays or human epidemiology to set standards for specific air pollutants. Hence we are developing short-term bioassays for genetic events in the pulmonary cells which would be suitable for identifying hazardous compounds. We have isolated fibroblasts from lung and shown that both gene mutations (at the hpt locus) and chromosomal aberrations can be detected in them when the animals have been exposed to pulmonary carcinogens. The optimal conditions found for each of the assays and the response to model lung carcinogens will be reported.

Specifically our experiments have utilized Chinese hamsters exposed to x-rays / urethane, both lung carcinogens, and other mutagens. Both dose and time responses have been studied and the animal-to-animal variability estimated. The results show that a study of a larger range of chemicals and of inhalation exposures is now feasible.

A5 **FIVE YEAR STUDY USING A MOBILE RAIN EXCLUSION CANOPY SYSTEM TO DETERMINE JOINT EFFECTS OF SIMULATED ACID RAIN AND OZONE ON THE GROWTH AND PHYSIOLOGY OF SUGAR MAPLE AND WHITE SPRUCE SEEDLINGS** Allen Kuja*, Murray Dixon, Ontario Ministry of the Environment, Air Resources Branch, Phytotoxicology Controlled Environment Laboratory, 100 Farmhouse Crt., Brampton, Ontario.

A fully automated rain exclusion canopy system is being utilized at the phytotoxicology controlled environment laboratory in a five year study to determine the impact of simulated acid rain (SAR) on the growth and physiology of potted sugar maple and white spruce seedlings established in field plots. All aspects of the field system are controlled by a micro-computer and data acquisition system. The system consists of three, mobile greenhouse shelters which exclude ambient rainfall. Simulated acid rain treatments are applied to test plants from nozzles arranged into two 5x5 latin squares in each canopy.

The joint effects of ozone and SAR are also investigated by means of an air exclusion system consisting of large blowers, potassium permanganate-treated alumina filters and perforated polyethylene tubes which force air into canopy treatment plots. Elevated, ambient levels of gaseous pollutants (e.g O_3, SO_2, NO_x) are reduced in plots of one canopy via the air exclusion system to minimize any interference with SAR treatment effects. Plots of the second canopy are exposed to controlled levels of ozone. Unfiltered, ambient air is blown into plots of the third canopy for control purposes.

Seedling response is measured in the following ways: 1. visible injury index, 2. plant dimensions, 3. photosynthetic rate (with a Licor 6200 P.S. analyzer), 4. chlorophyll analysis of leaf discs. Also, soil solutions are being collected via lysimeters from selected pots. Chemical analyses are being conducted on these samples.

A6 MONITORING ENVIRONMENTAL GENOTOXICITY USING SISTER CHROMATID EXCHANGES AND MICRONUCLEUS INDUCTION IN HOUSE MICE. Michael Petras*, Maria Vrzoc, Kathleen Hill and Caren Helbing, Department of Biological Sciences, University of Windsor, Windsor, Ontario.

Continuing contamination of our environment has resulted in a need for an EARLY WARNING SYSTEM TO MONITOR GENOTOXICITY IN THE GENERAL ENVIRONMENT. To this effect both wild and laboratory mice (Mus musculus) have been proposed as suitable test organisms. Two procedures, the SISTER CHROMATID EXCHANGE (SCE) TEST and a MICRONUCLEUS (MN) ASSAY FOR PERIPHERAL BLOOD ERYTHROCYTES have been adapted for effective use in mice exposed to natural conditions.

In the past twelve months we have continued to collect mice from corn cribs in southwestern Ontario and are analyzing these for SCEs and MN. After this summer we will have four years of data on SCEs and two on MN. To date both seasonal (related to farm practices) and geographic patterns have been observed for SCE levels. Last year's MN data, however, did not show such patterns and so this summer's results should give important insights. Along with sampling natural populations, laboratory mice have been put in corn-filled barrels placed at key sites in southwestern Ontario. These animals are replaced at regular intervals and the removed mice are tested for SCEs and MN. Besides giving seasonal and geographic patterns these assays have also provided "baseline values" against which future findings can be compared. Such values may become especially useful in determining the effects of new industries, new disposal facilities, accidental spills, etc.

Experiments have also been done to a) test the sensitivity of the assays under natural, possibly hazardous, conditions (e.g. tobacco barn, apple orchard), and b) determine the effects of biological factors (e.g. age, sex) and experimental conditions (e.g. bleeding protocols) on MN induction. The effects of such factors on SCEs has already been reported.

[Supported by: Ontario Ministry of the Environment Grant.]

A7

UTILIZATION OF ESTABLISHED AIR POLLUTION MONITORING NETWORKS IN ONTARIO FOLLOWING NUCLEAR INCIDENTS. J.A. Slade and S.H Linauskas, Atomic Energy of Canada Limited, Chalk River Nuclear Laboratories, Chalk River, Ontario.

This study, supported by the Ministry of the Environment, will examine the potential of using activated carbon impregnated filter paper for environmental monitoring of radioiodine with currently installed high volume air sampling equipment. Sources of carbon impregnated filter paper will be identified and samples obtained. Five suitable media types will be evaluated for both methyl-iodide and elemental iodine removal efficiency. The parameters which affect the removal efficiency of these two species, and which will be studied, include: carrier gas face velocity; relative humidity; and adsorbate concentration in the airstream. Recommendations on an approach to implementing a monitorig program utilizing this form of filter media will be presented, should the results be positive.

A8 CONTROL OF GASEOUS EMISSIONS AT THE BROCK WEST LANDFILL SITE.

R.E. Crysler, P. Eng., Trow Hydrology Consultants Ltd., 1595 Clark Blvd., Brampton, Ontario, L6T 4V1 and L. Sweers, P. Eng., Municipality of Metropolitan Toronto (Works), 439 University Avenue, Toronto, Ontario, M5G 1Y8.

In 1983 the Municipality of Metropolitan Toronto, assisted by Trow Hydrology Consultants Ltd., embarked on an extensive odour and gas control program at the Brock West Landfill Site to ensure a clean and healthy environment. This program consisted of the construction and installation of horizontal and vertical wells along with the required collection system, blower building and gas burners.

This paper will deal with the design construction, preliminary emission testing, modifications and final environmental gas emission testing program as required under Section 8 of the Environmental Protection Act of Ontario and for which partial funding was provided by the Ministry of the Environment.

A9

A PASSIVE DEVICE FOR THE MEASUREMENT OF AMBIENT SULPHUR DIOXIDE.

D.B.Orr*, J.C.Hipfner, W.H.Chan and M.A.Lusis, Air Resources Branch, 880 Bay Street, Toronto.
J.E.Hunt, Concord Scientific Corporation, 2 Tippett Road, Downsview.

The development and application of a simple passive device, which will be useful in helping to define long-term atmospheric sulphur dioxide concentrations, will be described. The device consists of a cellulose filter, impregnated with potassium carbonate/glycerol, which is shielded from the atmosphere by a membrane filter. Atmospheric gases pass through the membrane filter by molecular diffusion, while eddy motions are damped out. Sulphur dioxide is then selectively absorbed on the impregnated filter. After exposure to the atmosphere this filter is removed and analysed for the mass of sulphur dioxide. The mass (m) is related to the atmospheric concentration (c) and the exposure time (t) by

$$m = kct$$

where k is a diffusion constant. Once the device has been characterised by the determination of k, this relationship allows the calculation of concentrations from the measured filter loadings and the known exposure times. The results of tests in the laboratory and the field will be presented, together with a description of further developments of the device.

A10 **LABORATORY SCALE TESTING PROGRAM TO DEVELOP UNDERSTANDING OF A PHOTOCHEMICAL FLUE GAS TREATMENT PROCESS.** P. Fellin, K. Brice, C.S. Fung, J.E. Hunt*, Concord Scientific Corporation, 2 Tippett Road, Dowsview, Ontario, M3H 2V2.

A laboratory bench-scale study was conducted at Concord Scientific Corporation to develop an understanding and determine feasibility of using ultraviolet light for initiating reactions to remove SO_2 and NO_x from flue gas streams typical of those found in emissions from coal-fired power plants. The design, construction, and characterization of a quartz reactor system was completed. The system allows close control of parameters such as temperature, flow rates, light intensity, and test gas composition with respect to carrier gases (N_2, O_2, H_2O) and target gases (SO_2, NO). A major challenge, in terms of the design, was achieving stable reactor gas temperatures at elevated levels (250°C) while at the same time operating the nearby light sources at temperatures between 40 and 60°C. The reactor was used to systematically evaluate removal efficiencies, process kinetics, and quantum yields of the process. Results were evaluated by utilizing a computerized photochemical kinetic model incorporating best estimates of kinetic rate constant from reported literature. The techniques, results and analyses of data are presented in this paper.

All

TESTING A COMPREHENSIVE ACID DEPOSITION MODEL. **P.K. MISRA, R. BLOXAM*, Air Resources Branch, Ministry of the Environment, Toronto, Ontario.**

The evaluation of a comprehensive model gives rise to a number of problems which include those associated with uncertainties in the data used to run and evaluate the model. Additionally, the inherent complexity of the model makes it difficult to ascribe discrepancies between model predictions and observations to any one source (or several sources) of errors. This paper shows that the solution of these problems requires an iterative cycling between model formulation and testing with observations. We also demonstrate the need to supplement traditional methods of model validation with techniques that provide information on how well the model captures the essential features of important atmospheric processes.

We illustrate the steps of model testing through an analysis of results from the simulation of an acid deposition episode with the comprehensive model ADOM (Acid Deposition and Oxidant Model). Model predictions of sulfate and nitrate in rain are compared with corresponding observations. In addition, the predictions are used to estimate event-averaged washout ratios. It is found that these washout ratios agree well with those estimated from recent observations. The geometric mean washout ratios for SO_2 (5×10^4) and SO_4 (6×10^3) are comparable to those used in semi-empirical long-range transport models.

RE1172

A12 AN EULERIAN MODEL OF LONG RANGE TRANSPORT OF AIR POLLUTANTS AND ACID RAIN.

Han-Ru Cho* and J.V. Iribarne, Department of Physics, University of Toronto, Toronto, Ontario, M5S 1A7

An Eulerian model of long-range transport is being developed for air pollution and acid rain studies. The model is based on an mesoscale weather prediction model with a domain covering the entire North American Continent. An important feature of the model is the detailed cloud microphysical processes which includes six species of cloud and precipitation particles: cloud water vapor, cloud droplets, cloud ice, raindrops, snow, and graupel. Such detailed cloud microphysics has not been introduced before into Eulerian models of this scale. Incorporated into the model is also fairly complete in-cloud chemistry of SO_2 and NO_x, including oxidation of SO_2 in liquid phase by H_2O_2, O_3, OH, and HO_2, and oxidation of NO_2 and NO in gaseous phase by OH. The purpose of the model is to provide a mathematical tool for the study of physical and chemical processess affecting long-range transport and acid rain, particular those processes involving clouds and cloud systems. At present, the model is being used to simulate the meterological and air pollution fields during OSCAR period 4, when a strong frontal system dominated the flow field of central and eastern North America. Results from this simulation will be reported.

A13 SPATIAL AND TEMPORAL VARIABILITIES OF ACID RAIN LEVELS IN ONTARIO. Edward A. McBean*, Michael Kompter, John Donald, Scott Donald and Grahame Farquhar, Department of Civil Engineering, University of Waterloo, Waterloo, Ontario, N2L 3G1, Canada.

The monitoring of acid rain represents an expensive but essential task for Ontario. The specification of the intensity of the monitoring network in terms of spatial resolution is an integral part of the monitoring requirements. The intent of this paper is to describe two approaches to address the question of monitoring intensities, namely:

(i) statistical analyses of the monitoring data. These analyses examine the degree of variability of concentration and deposition data and the degree of causative roles of precipitation and wind direction. As well, the ability of monitoring locations to be used collectively in the context of an "airshed" in an attempt to obtain additional grouped measures of deposition rates, is employed; and,

(ii) the second approach utilizes a long-range transport model to relate changes in emission levels to changes in deposition levels. This procedure introduces specific mechanistic principles that impact long-range acid rain transport.

A major focus of the research was to determine the degree of impact of the emissions at Sudbury.

A14 MODELLING THE PHOTOCHEMICAL DECOMPOSITION OF CHLORINATED PHENOLS BY SUNLIGHT. Nigel J. Bunce* and Jamie S. Nakai, Department of Chemistry and Biochemistry, University of Guelph, Guelph, Ontario N1G 2W1, Canada.

The objective of this work is to estimate the importance of the direct solar photodegradation of chlorinated phenols as a sink for these compounds in the atmosphere. Generally, the decomposition of any atmospheric pollutant by sunlight depends upon four factors: the solar radiation flux, the pollutant concentration, the pollutant absorption spectrum, and the quantum yield (or efficiency) of the photochemical decomposition. The former two quantities are available from the literature, the latter two by experimental measurement. Of key importance in determining the direct photolysis rate is the overlap between the tropospheric solar spectrum and the absorption spectrum of the pollutant. Photodecomposition rates have been estimated for several members of the chlorophenol family. There is a general trend towards lower quantum efficiency as the number of chlorine atoms in the phenol increases, but this effect is more than offset by increased spectral overlap, with the result that pentachlorophenol is the most photolabile of all the substances studied to date. Its half life for simulated solar decomposition is less than a day.

The direct photolysis rates have also been compared with the rates of attack on the same substances by hydroxyl (OH) radicals, another important reaction pathway for volatile organic compounds. The chlorophenol family has members both more reactive by solar photodecomposition (e.g. pentachlorophenol) and members such as 2-chlorophenol which are predicted to react principally with OH radicals.

A15 VECTOR SCORING SYSTEM FOR THE PRIORITIZATION OF CHEMICAL CONTAMINANTS. A.C. Socha and the Priority List Working Group, Ontario Ministry of the Environment, Toronto, Ontairo; CanTox Inc., Oakville, Ontairo.

There are many thousands of chemical substances which may be present in the environment. It is not possible to simultaneously evaluate the impact of all of these chemicals. In order to develop a manageable list of substances with high priority for multimedia standards setting, the Ontario Ministry of the Environment is developing a vector scoring system. In this system, chemicals are assigned numerical scores for various parameters, or "vector elements", which describe their environmental behaviour, exposure potential, aesthetics, and adverse effects on human, plant and animal life. The scores for individual elements are combined in specific ways to arrive at a priority ranking for contaminants. The system is divided into three phases, each phase requiring more specific information about a chemical than the preceding phase. Chemicals are selected for assessment in subsequent phases according to their ranking in the preceding phase. Once scores are generated, substances ranked as highest priority will receive first consideration for regulatory assessment. This system has recently been adapted and applied in the selection of substances to be monitored for in municipal and industrial effluents, as part of Ontario's MISA pollution abatement program.

A16

RECEPTOR MODELLING OF AMBIENT AIR PARTICULATES AT EAST RIVERDALE AND TORONTO CONTROL SITES

R.E. Jervis*, T.G. Pringle and A. Chan, Dept. of Chem. Eng. and Applied Chemistry, University of Toronto.

Further research has continued during 1987 into the capabilities of multielemental receptor modelling of the CEB, chemical element balance approach, to identify individual emission sources at a particular receptor site and to delineate their respective contributions.

As a data bank to which to apply factor analysis and CEB, the concentrations of 30-40 chemical elements in ambient air particulate matter have been measured at several Metro Toronto sites including an Eastern Av. location: both Hi-Vol air filters and collectors from 6-stage cascade impactors have been taken over various sampling periods and multielemental analysis performed by radioanalytical INAA and IPAA methods.

Size-sorting sampling was undertaken as a means to differentiate sources having similar concentration 'profiles' but different particle-size distributions. In the interests of assessing how effective this approach is, results from the E. Riverdale site have been subjected to receptor modelling (i) as size-fractionated and (ii) as total particle collections. The details of how superior the former method is will be detailed in this paper.

In the above measurements, a discernible contribution from waste and sewage incinerators to I,Se,Ni,Zn,Pb,Sb levels could be discerned. A more thorough Hi-Vol and impactor sampling program has been initiated in a down-wind area to further investigate waste incinerator impacts in urban airsheds. For reference, Hi-Vol air sampling was done at Queen's Park in Metropolitan Toronto since January, 1987 and the Whatman paper filters analyzed by neutron activation. Results for up to 35 elements were obtained for 25 filter sets and subjected to statistical factor analysis and chemical element balance to identify major sources and their contributions.

A17 DEVELOPMENT OF MULTIVARIATE ANALYSIS PROCEDURES FOR ONTARIO AIR QUALITY DATA. P.K. Hopke, Institute for Environmental Studies, University of Illinois at Urbana-Chanmpaign, Urbana, IL.

The objective of this project is to examine the use of advanced pattern recognition methods and multivariate statistical procedures for maximal extraction of information regarding origins, transport, and deposition of airborne pollutants in Ontario. The initial phase of the project is focusing on the Event Wet/Dry Deposition Network data obtained by the Acidic Precipitation in Ontario Study (APIOS). Two types of eigenvector studies will be initially tested; principal components analysis incorporating back trajectory calculations, and three-mode factor analysis. By coding the endpoint geographical region of the back trajectory as an additional variable, it is anticipated that the components analysis may provide additional insights into the origin and transport of the measured species. Three-mode factor analysis is a relatively unknown method for simultaneously looking at the spatial and temporal variations in a multivariate data set. It is a model that explicitly allows the use of multilocation data over time and it is again anticipated that it will provide new insights into the interrelationships that govern the pattern of species deposition as measured by the APIOS network.

A18

CONTINUOUS MONITORING OF OPACITY, TOTAL HYDROCARBONS AND CARBON MONOXIDE IN AIR EMISSIONS FROM BIOMEDICAL WASTE INCINERATORS. G. Marson, V. Ozvacic, Air Resources Branch, Toronto, Ontario.

New incinerators of biomedical waste in Ontario must be equipped with continuous emission monitors for opacity and total hydrocarbons or carbon monoxide. Purchase of adequte instruments, their installation, operation and maintenance could present difficulties due to high temperatures, corrosive nature of emission gases and the intermittent operation of the incinerators. In order to examine these conditions and to specify appropriate policy guidelines, the Air Resources Branch has undertaken an experimental investigation using commercial instrument packages at two incinerators in Toronto. This paper presents the main findings of the study.

The main conclusion of the study is that useful measurements of the three measured parameters could be obtained on continuous basis, providing proper installation and operation procedures are followed. Opacity readings could be affected by a glow caused by high temperatures, however, the measurement error is small in comparison to opacity levels of concern. No erroneous readings were recorded in the case of total hydrocabons and carbon monoxide.

The instruments were found particularly useful for prompt detection of nonstandard operation of incinerators and the measurements correlated well with process operation and visual emissions.

AP1

IDENTIFICATION OF AIRBORNE PARTICULATES. T. Kilner,* Math, Physics & Computer Science, S. G. Lea, Applied Chemical and Biological Sciences, Ryerson Polytechnical Institute, 350 Victoria Street, Toronto, Ontario M5B 2K3.

A method has been developed for the identification of airborne particulate matter by the techniques of electron optics. Samples of this matter, in the form of dust, is mounted in resin and sliced on a micro tome using a diamond knife. These sliced samples are then affixed to standard microscope grids and put in a scanning transmission electron microscope with provision for energy dispersive chemical analysis, as well as standard electron diffraction pattern study.

This technique allowed the identification of dust particles in most cases, and was found to be a fast and reliable method for preparation of samples. The diamond knife was also found to exhibit no visible wear due to cutting.

AP2

THE EFFECT OF pH, ALUMINUM AND DROUGHT ON SUGAR MAPLE SEEDLINGS.

Vic Timmer, Magda Havas* and Tiina Pajos. Faculty of Forestry and Institute for Environmental Studies, University of Toronto, Toronto, Ontario, M5S 1A4.

Dieback of sugar maple trees in Ontario, Quebec and New Brunswick may be linked with air pollution in the form of acid rain. Acid rain leaches aluminum from soils and converts it to a form that can be toxic to plants. Aluminum interferes with root growth, uptake of nutrients and water. Drought, in areas receiving acidic rain, may increase aluminum toxicity and accelerate the death of plants. The purpose of the present study was to determine the effect of acid rain and drought on growth and chemical composition of sugar maple seedlings.

Sugar maple seedlings grown in soil for 4 weeks had lower root biomass at pH 2.5 and 3.5 compared with pH 4.5 and 5.5. These stunted roots also had higher Al concentrations. In sand culture, Al was added since sand is relatively inert and we wanted to separate the effects of pH from those of Al. Root and shoot Al concentrations increased in the high Al treatments (100 and 250 mg/L), especially at low pH. Aluminum appeared to interfere with Ca uptake. Difficulty of inducing drought in small pots lead us to a third experiment with polyethylene glycol. The results for these three experiments will be presented.

AP3 **CONCENTRATIONS OF PCDD AND PCDF IN SOIL FROM THE VICINITY OF A LARGE REFUSE INCINERATOR IN HAMILTON, ONTARIO.** D.L. McLaughlin, R.G. Pearson* and R.E. Clement, Ontario Ministry of the Environment, Air Resources Branch, Phytotoxicology Section, 880 Bay Street, Suite 347, Toronto, Ontario.

In 1983, the Phytotoxicology section, Ontario Ministry of the Environment, was requested to conduct a soil sampling assessment survey in the vicinity of a large municipal refuse incinerator near the western tip on the south shore of Lake Ontario in the City of Hamilton. The incinerator, which began operation in 1973, consists of two boiler units venting through separate flues in a 50.3 m stack. The location of the maximum ground level concentration (c-max) was calculated at 1182 m.

In 1982 and 1983, stack testing for organic emissions, including PCDDs and PCDFs, was conducted. These findings confirmed an average annual PCDD and PCDF stack output of 4.3 and 10.5 kg/yr, respectively.

At each of 14 sites, surface soil (0-5 cm depth) samples were collected using a modified EPA protocol within a 2 m diameter circular plot. All samples were returned to the MOE Dioxin Laboratory where they were ground, weigned and air dried. Analysis was contracted out to a private laboratory.

On the basis of the PCDD and PCDF soil analyses results, it was concluded that PCDDs and PCDFs emitted from the incinerator since 1973 have not accumulated in the surface soil in the vicinity of the source. This was based on the following factors:

1. PCDDs were detected at all 11 survey area sites and at each of the three control locations.
2. PCDFs were detected at eight of the 14 sites, including both of the urban control locations but not at the remote/rural site.
3. PCDDs and PCDFs were not elevated in the vicinity of the calculated maximum ground level concentration.
4. A concentration gradient relative to distance or direction from the stack was not detected.

AP4

DOSE RESPONSE FOR SELECTED ENVIRONMENTAL AIR POLLUTANTS: A STUDY ON RUNNERS. R. Bruce Urch,* Frances Silverman, Paul Corey and Roy J. Shephard, The Gage Research Institute, Departments of Medicine and Preventive Medicine and Biostatistics, and School of Physical and Health Education, University of Toronto.

People running in an urban environment may be at greater risk since their ventilatory rate is increased, thus increasing the dose of pollutants that they are exposed to. Factors affecting the runner's pollutant load include: exercise intensity (thus ventilation rate), mode of inhalation (mouth vs nose breathing) and running through areas of high pollution. This study examines health effects of air pollution on runners during training runs in downtown Toronto over a three year period, 1986-1988.

Subjects are selected from the Longboat Roadrunners Club which carries out weekly training runs covering an area in downtown Toronto and along the Lakeshore corridor during rush hour. Pulmonary function and carboxyhaemoglobin (COHb%) are measured before and after the run; individual performance, subject evaluations, respiratory symptomatology and other health/illness information are also obtained. Pollutant measurements for each run include SO_2, oxides of nitrogen (NO_x, NO, NO_2), O_3, CO and suspended particulate matter along with environmental covariates (temperature, humidity, wind velocity and direction). Existing central Toronto air pollution monitoring network data (central MOE) is supplemented by portable personal multipollutant samplers (SO_2, NO_2 and respirable particulate matter) placed at the central station (GMOE), and carried on bicycle following the runners (mobile GAGE). The mobile bicycles also carry CO and temperature/humidity samplers.

Data from three run seasons (April-October) will be evaluated: 1) for differences between central MOE, GMOE and mobile GAGE assessments of exposure, 2) for the relationship between pollutant exposure during runs and changes in pulmonary function, COHb%, and symptom reports, separately for each of the above monitoring "networks".

The study design will be presented along with preliminary data from the first years "run season".

Ap5 **STUDY TO DETERMINE THE PHYTOTOXICITY OF CALCIUM MAGNESIUM ACETATE (CMA) ON FRUIT TREES AND ORCHARD SOILS IN THE NIAGARA PENINSULA.** R.G. Pearson and G.N. Vasiloff*, Phytotoxicology Section, Air Resources Branch, Ministry of the Environment, Toronto, Ontario.

During the winter of 1986/87, the Ministry of Transportation and Communications tested CMA as a possible alternative to road salt along a 2.4 km portion of the Queen Elizabeth Highway (QEW) and adjacent service roads in the Niagara Peninsula. The Phytotoxicology Section was invited to study the environmental impact of the test material on nearby fruit trees and orchard soils. Plum and peach tree species were selected and tagged at three locations within the CMA test zone and at four salt control locations. Species locations and distances from the QEW were similar at each of the seven study locations.

Prior to the application of CMA and salt, twig and soil samples were collected from all sites for determination of background chemical concentrations. In the spring, tagged twigs from each study tree were evaluated for chemical injury and excised for chemical analysis. Soils were also re-sampled in the spring for analysis.

In order to monitor the comparative lateral aerial movement of CMA and salt at the study locations, ion receptor moss bags were erected within the crown of each study tree at increasing distances into the orchards and at approximately 300 m intervals within the CMA application area along both the north and south service roads. Bags were deployed immediately following the first application of CMA and road salt (November 20, 1986) and exchanged monthly until the end of April. Following each moss bag exchange, the moss was chemically analyzed for calcium, magnesium, sodium and chloride plus several other tracer elements associated with emissions from a traffic artery.

In view of the relatively mild and snow reduced winter which was experienced in 1986-87, the MTC has decided to repeat the CMA application during the winter of 1987-88. The environmental monitoring of the orchard trees and soils also is planned for repeat study.

AP6 ESTABLISHING VEGETATION ON EROSION-PRONE LANDFILL SLOPES IN ONTARIO. T.W. Hilditch and C.P. Hughes, Gartner Lee Limited, Markham, Ontario.

The erosion of a landfill cover can negatively impact upon its function and longevity.

The first year of a three year study has contributed to an understanding of the extent and severity of landfill erosion in Ontario. The aim of the program is to develop an approach to remediate landfill erosion through vegetation management.

Literature was reviewed and individuals involved with North American landfill research were contacted. Approaches to landfill revegetation were identified and assessed.

Each MOE District Office and Sub-office was asked to respond to a questionnaire. Through that survey, details of landfill erosion were obtained and example sites were identified. Responses indicate that landfill erosion is considered to be a moderate concern in most Districts. In a few cases, it was reported to be a serious concern.

Twenty-four landfills (four from each of the six MOE Regions) were field-checked to identify in detail, the physical and biological characteristics of each. Twelve will provide locations for test plot planting and monitoring of preferred revegetation treatments. Those activities will be completed during the remaining two years of study.

A provincial manual for the revegetation of landfills will be one of the products of this project.

AP7

EVALUATION OF A HI-VOL DENUDER SORBENT SAMPLING SCHEME FOR MEASUREMENTS OF POLYNUCLEAR AROMATIC HYDROCARBONS

G.Diamond* and A.Szakolcai, Ont. Min. of Environment, 880 Bay St.,4th Fl., Tor., Ont.; J.Osborne and S. Burns, Ont. Min. of Environment, 125 Resources Rd., Rexdale, Ont.

A series of field tests have been performed to determine the suitability of a modified Hi-Vol sampler for field measurements of PAH's.

Sampling was performed with a modified hi-vol sampler altered to include a cartridge of XAD-2 sorbent downstream of the filter to collect the volatile PAH's not collected by the filter or volatilized from it. The filter used was a teflon-coated glass fibre filter. A removable ozone denuder could be added to the system upstream of the filter to minimize on-filter reactions between collected PAH's and ozone. All sampler exhausts were vented away from the site to avoid resampling the same air volume. Sampling was done for 24 hour periods at flow rates of about 590 litres per minute. Field blanks accompanied all samples to and from the field sites and were analysed at the same time as the samples. Analysis of the samples was accomplished with HRGC/dual FID.

Three separate tests were conducted. Two series of side by side comparisons were run in Windsor and Hamilton to study the reliability of the sampling and analytical methods. A breakthrough study was undertaken to ascertain if one resin cartridge was sufficient to adsorb all of the more volatile PAH's. A side by side comparison of a sampler with a denuder and one without one was performed to test the effectiveness and necessity of the denuder.

AP8

EFFECT OF FINE PARTICLES ON RESPIRATORY HEALTH IN A COHORT OF YOUNG PEOPLE.

L.D.Pengelly *, A.T.Kerigan, and C.H.Goldsmith; McMaster University, 1200 Main St. W., Hamilton, ON L8N 3Z5.

In Hamilton, ON, we have carried out a series of studies of the effect of the environment on the respiratory health of a cohort of young people. The studies cover the years 1979-1985 inclusive, and over this period we have examined over 4200 children at least once, and close to 1800 children five times. Continuous measurements of particle size fraction were made from our network on the North American Synoptic 6-day Cycle for the period Jan. 1979 to Jun. 1986, allowing us to quantify exposure to the fine fraction of suspended particles (FF, <3.3um). We now have the longest and most extensive record of urban fine fraction yet reported.

The results of our study show that there is a systematic gradient in FF concentration over Hamilton, which varies from year to year. The annual mean for one site in the lower city exceeds 60 ug/m3 for all of this period except 1985, but an upper city site shows 15 to 20 ug/m3 less for all years.

The presence of this gradient allows for the examination of the effect of FF on respiratory health. In a previous report we demonstrated a negative effect of FF on pulmonary function measured in 1980. We have not seen a negative effect of FF on pulmonary function measured in 1983-84. We have observed, however, a high rate of smoking in the cohort, particularly among female teenagers, and this smoking can already be shown to be associated with significant reductions in lung function in this group.

(Supported by Ontario Ministry of the Environment)

AP9

OUTDOOR SOUND LEVEL PREDICTION FOR INDUSTRY, 1986, Tim Kelsall,* Hatch Associates Limited, 21 St. Clair Avenue East, Toronto, Ontario M4T 1L9

Canadian Standard Association Standard Z107.55, Recommended Practice for the Prediction of Sound Levels at a Distance from an Industrial Plant, was published recently. Two tasks associated with this standard were undertaken in the study being reported here.

A software package was prepared which follows the standard and simplifies its use. This should facilitate routine use of the standard.

In addition, the validity of the standard was evaluated by comparison with other predictions and measurements reported in the literature. The standard was found to be slightly less accurate under some conditions than similar European standards, but significantly less complicated.

Verification of the standard on existing plants is recommended as future work.

AP10 THE DEPOSITION OF HEAVY METALS AND ACIDITY IN ONTARIO. N. Reid, D. Orr and M. Lusis, Environment Ontario, Toronto, Ontario.

Trace metal concentrations in air and precipitation are monitored in a network in Ontario, along with concentrations of chemical parameters related to acidity (e.g., pH, sulphate and nitrate). These data have provided the basis for estimates of direct atmospheric input of toxic metals to the Great Lakes. In addition, a special metals monitoring program is under way at one location, including the determination of species such as indium, germanium and arsenic, which are known, or believed, to be tracers for large point sources. Results from this study will assist in the assessment of impacts due to these large sources in acid sensitive areas.

B1 MONITORING OF ORGANIC CONTAMINANTS USING FRESHWATER MUSSELS. D. Innes, R. Lazar, D. Haffner*, P. Hebert. Great Lakes Institute, University of Windsor, Windsor, Ontario N9B 3P4.

Freshwater mussels are potentially useful biomonitors since they filter the surrounding water and have been shown to accumulate organic contaminants to detectable levels. Uncontaminated individuals of E. complanata were collected from Balsam Lake, Ontario and deployed at different depths in the St. Clair River near Walpole Island (3 sites) and in Lake St. Clair (2 sites) during July - October, 1986. Mussels were sampled at 3 week intervals and analyzed for HCB, OCS and QCB using ECD-GC. After 20, 40 and 60 days exposure, mussels deployed in the St. Clair River accumulated significantly greater concentrations of all three contaminants compared to mussels deployed in Lake St. Clair. No differences in contaminant concentration were observed between mussels exposed near the surface and mussels exposed on the bottom. Mussels exposed in the St. Clair River continued to accumulate contaminants after 60 days exposure with no decrease in the rate of accumulation. Seasonal differences in contaminant accumulation were also observed. Laboratory experiments are in progress to measure the uptake kinetics of these contaminants.

B2 MERCURY IN BENTHIC INVERTEBRATES FROM PENINSULA LAKE AND LAKE VERNON. M. Allard* and P.M. Stokes, Institute for Environmental Studies, University of Toronto, Toronto, Ontario, M5S 1A4.

Benthic invertebrates from two lakes remote from Hg point sources were sampled. One of these lakes had high fish Hg (Lake Vernon) while the other one had lower fish Hg (Peninsula Lake). Mercury was determined in different invertebrates monthly collected (June-October 1986) at several sites on each lake. One of our objectives was to evaluate the importance of species, sites (or lakes) and season on the bioaccumulation of mercury in invertebrates in order to determine the origin of the mercury present in the biota.

Hg concentrations were significantly different among species, the following increasing order was observed: mayflies, oligochaetes < mussels < snails.

Mercury concentrations in the snail Campeloma decisum were significantly varying among sites, lakes and sampling months. Snail Hg in Vernon was only slightly higher than in Peninsula lake. Hg concentrations in the mayfly Hexagenia sp and in oligochaetes, were not significantly different among the two lakes, sites or sampling month. Cambarus bartoni (crayfish) and Elliptio complanata (mussel) from Lake Vernon had much higher mercury than those from Peninsula lake.

Crayfish Hg was higher in Vernon stream than in the lake; while comparisons among miscellaneous organisms revealed that for a given mean weight, organisms body burden are higher in the stream than in the lake.

Our results, particularly higher Hg in organisms living at sediment-water interface (such as crayfish and mussels), the absence of Hg differences between sites for organisms living in sediments, and the presence of lake/stream differences indicate that water Hg, especially stream water, might contribute more to benthos Hg than sediment Hg.

B3 TEMPORAL AND SPATIAL VARIATIONS IN METAL CONCENTRATIONS OF ZOOPLANKTON IN CENTRAL ONTARIO LAKES.

Gerry Mackie* and Norman Yan, Department of Zoology, University of Guelph, Guelph, Ontario N1G 2W1 and David Boomer, Ontario Ministry of the Environment, Rexdale, Ontario M9W 5L1

Zooplankton samples were collected on a single occasion from 32 lakes (6 near Sudbury) located along a transect southeast from Sudbury and at two week intervals from April to November in 1985 and 1986 from a low alkalinity lake (Plastic Lake) and in 1986 from a circumneutral lake (Red Chalk). The samples were analyzed for metal levels using ICP (Inductively Coupled Plasma) Mass Spectroscopy for Co, Cr, Ni and Pb, and ICP Atomic Emission Spectroscopy for Ca, Mg, Sr, Fe, Mn, Ti, Sc, Ba, Be, Cd, Cu, Zn and Al. Accuracy and precision checks with certified material and sample:blank ratios forced rejection of some metals. Useful data were obtained for 13 metals: Ca, Mg, Zn, Fe, Cu, Mn, Sr, Cd, Ti, Al, Ni, Be, Ba. The temporal and spatial variations in metal levels of zooplankton were compared to the pH, alkalinity, Ca content, and dissolved organic carbon level of the lake water, and to the composition of the zooplankton communities. The 6 Sudbury lakes have higher levels of Cu and Ni but lower levels of Ca, Sr, Ba and Mn than the remaining lakes. Temporal variations in metal levels of zooplankton are greater in the low alkalinity lake than in the circumneutral lake. Some metals show as much (e.g. Ca, Mg, Mn) or greater (e.g. Sr, Ba) temporal variance than spatial variance. Three distinct seasonal patterns are present for groups of metals: Mn, Ca, Sr, Ba; Ti, Fe, Al; Mg, Zn. Cd displays a unique seasonal pattern. Some of these patterns may be attributable to seasonal changes in pH, alkalinity and Ca and Al contents of the water. Ca content of zooplankton correlates (Spearman Rank) strongly and positively with increasing proportions of *Daphnia pulex* biomass.

B4 AVAILABILITY OF ZINC TO BENTHIC ORGANISMS FROM SEDIMENT FRACTIONS.

Daniel Andrews* and Jerry Fitchko, BEAK Consultants Limited, 6870 Goreway Drive, Mississauga, Ontario L4V 1P1

This study, supported by the Ministry of the Environment used a novel radiolabelling technique to examine the bioavailability of zinc in Toronto Harbour sediments to benthic oligochaetes. Sediment from Toronto Harbour were labelled with zinc-65 and used as a culture medium for two species of benthic oligochaetes, Tubifex tubifex and Limnodrilus hoffmeisteri for periods of one and two months. By comparing the specific activity of zinc-65 in each of six chemical fractions of the sediments with the specific activity of zinc-65 in the worms, the zinc fraction bound to iron and manganese oxides was clearly identified as the source of this metal to these tubificids. Chemical fractionation of zinc with depth in cores taken from Toronto Harbour demonstrated that 45-70% of sedimentary zinc is available to these oligochaetes. Separate labelling experiments showed that zinc released into an aquatic environment is bound within minutes to particles in the water column or the sediments. Most of the introduced zinc (over 90%) is taken up by the Fe/Mn bound and carbonate-bound fractions while only small quantities are taken up by the organically bound, residual, easily-exchangeable and interstitial zinc fractions. Comparison of the specific activities of each fraction indicated that the easily-exchangeable fraction exchanges most rapidly and the organic fraction least rapidly with zinc introduced into the aquatic environment.

B5

APPLICATION OF THE FUGACITY/ACTIVITY MODEL TO PREDICTING THE BEHAVIOUR OF ARSENIC IN LAKES.

M.L. Diamond*, D. Mackay, Institute for Environmental Studies, University of Toronto, Toronto, Ontario.

To provide a general and easily understood environmental model capable of predicting the fate of contaminants, our group has developed a family of models based on thermodynamic principles. The central concept is that concentrations are replaced by an equilibrium criterion, thus simplifying expressions for intermedia transport. For organic chemicals that partition between air and water phases, fugacity is the equilibrium criterion used. For inorganic contaminants that have a negligible vapour pressure, activity is preferable. Both fugacity and activity are linearly related to concentration, and models written in any of these terms are ultimately mathematically equivalent.

The objective of our research is to develop a mechanistic model for inorganic contaminant movement in fresh waters. We first apply the model to arsenic in Moira Lake located in eastern Ontario, which has received arsenic inputs from an upstream, abandoned mine facility for over 100 years.

The model comprises two compartments; lake water which includes dissolved arsenic and four size classes of suspended particulates (0.4 to 110 um), and lake sediments which consist of pore water and solid sediments. Movement of arsenic is by advection, bidirectional diffusion of dissolved arsenic between the water and sediments, and sedimentation and resuspension of particulate arsenic.

To test the model we have obtained data from the Ministry of the Environment as well as from our own field studies of the lake. Details of the model calibration, goodness-of-fit, sensitivity and the applicability of the model to other metals in other systems are discussed.

B6 DEGRADATION OF ORGANIC CONTAMINANTS BY ANAEROBIC BACTERIA IN LAKE ONTARIO SEDIMENTS. I. Strycek, M. Urbanek*, C. Wyndham and M. Goldner, University of Toronto, Toronto, Ontario.

Anaerobic bacteria from sediment slurries from two sites in Lake Ontario were cultivated in the presence of halogen derivatives of benzoic acid. Biodegradation was assessed by net gas (CH_4, CO_2) production by pressure transducer and GC or by substrate disappearance by HPLC. The anaerobic consortium enriched by dilution in a minimal anaerobic medium from Toronto Harbour slurry was characterized by high metabolic activity indicated by positive gas production and rapid substrate depletion in comparison to the Humber Bay site. A characteristic pattern of biodegradation was exhibited with a preference for the metabolism of 3-bromobenzoate and 3-iodobenzoate in comparison to 3-chlorobenzoate in enriched samples. Degradation in the original harbour sediments supplemented with anaerobic minimal medium exhibited a prolonged lag phase in comparison to enriched anaerobic consortia. HPLC analyses detected a tansient accumulation of benzoic acid in the cultures during biodegradation, indicating a possible reductive dehalogenation of the substrates. Enriched bacterial consortia exhibited characteristic morphologies by phase contrast and epifluorescence microscopy. The results indicate the potential for anaerobic mineralization of halogenated contaminants in Lake Ontario sediments.

B7 THE EFFECTS OF TILE DRAINAGE AND OPEN DITCHES ON PEAK FLOWS AND DRY WEATHER FLOWS. J.D. Paine*, W.E. Watt*, Department of Civil Engineering, Queen's University, Kingston, Ontario.

The object of this study was to investigate the hydrology of the agricultural drainage process, and to assess its impacts with respect to flows and volumes of water conveyed to receiving streams. The impacts of both tile drainage at the field level and ditch drainage at the small basin level were considered and analyzed through the use of a physically-based hydrologic model capable of simulating the drainage process continuously through the frost free period. Two test fields in southeastern Ontario provided the data for model development and ultimately calibration and verification of the field component. A partly tiled subbasin of the Wilton Creek watershed was used as the study basin for the determination of drainage impacts at the small basin level.

The data collection program and the techniques for the practical measurement of physical parameters for the test fields are described. The applications of the model to the evaluation of the hydrologic impacts of tile drainage are discussed.

B8 AN EXPERT SYSTEM FOR WATER QUALITY ASSESSMENT.

W.P. Allen*, T.E. Unny, H. Shen, Department of Systems Design, University of Waterloo, Waterloo, Ontario, N2L 3G1, Canada. L. Logan, Hydrologic Unit, Water Resources Branch, Ontario Ministry of the Environment, Toronto, Ontario, M4V 1P5, Canada.

WatQUAS - a prototype expert system that has been developed to interpret historical water quality data is described. The expert system mimics a human hydrological expert in judging the statistical analysis of a time series representation of water quality at a site. The system incorporates standard statistical analysis techniques and knowledge engineering methods in interpreting the data based on hydrological heuristics compiled in a knowledge base.

Expert system applications avoid many of the pitfalls of traditional computer software packages. Expert systems are a type of Knowledge Based System - a system which relies on machine 'understanding' of problems rather than rigid mathematical algorithms. For this reason, expert systems are often designed to accommodate symbolic information and making conclusions regarding the meaning of the data.

Water quality assessment as a branch of hydrology incorporates both deterministic facts such as concentration measurements and quantifiable geographical situations with the more obscure concepts of environmental risk assessment and socio-economics. Part of the water quality expert's task is to pass judgement on data and attach symbolic meanings to the data. The interpretive procedure is ill-defined and resists conventional modeling methods. In fact, hydrologists quite often differ among themselves as to what knowledge is relevant and how to define the interpretive procedure. This ambiguous nature of water quality assessment makes it an excellent candidate for an expert system application.

B9

TRACE ORGANIC CONTAMINANT REMOVAL IN THE CONVENTIONAL WATER TREATMENT PROCESS 1987. John N. Hilton and Robert F. Machacek, MacLaren Plansearch Inc., Toronto, Ontario

This study was designed to investigate the removal of synthetic organic compounds (SOC's) firstly in a conventional water treatment process and, subsequently, using granular activated carbon (GAC) contactors in an add-on mode to the conventional process. This paper deals with the investigations and the results of work on the assessment of the conventional treatment process. As a first step, 8 primary and secondary coagulants were evaluated using a matrix of coagulant dose and pH combinations. Turbidity, dissolved organic carbon (DOC) and ultraviolet absorption at 254 nm (UVA) were the parameters used to assess performance. The most promising combinations were subsequently evaluated in a 3.8 L/min pilot plant. One of the best combinations - polyaluminum chloride (PAC1) at 8 mg/L and pH = 7 - was used to investigate the removal of SOC's in the pilot plant. A spiking mixture of gamma-BHC, p,p-DDT, decachlorobiphenyl, naphthalene, anthracene, pyrene and 2,4,6-trichlorophenol was injected into the raw water and measured before treatment, after the clarifier and after the filter. The behaviour of these hydrophobic compounds in surface water will be discussed in the interprepation of the results of the study.

B10 QUANTITATIVE STRUCTURE-ACTIVITY RELATIONSHIPS FOR ORGANIC COMPOUNDS AND THEIR MIXTURES.

A. Smith, G. Ozburn, and L. McCarty. Aquatic Toxicity Research Group, Lakehead University, Thunder Bay.

With MOE funding the ATRG has collected a comprehensive and detailed database on the acute and chronic toxicity and the bioconcentration of selected groups of organic chemicals: chlorinated benzenes, chlorinated phenols, and chlorinated ethanes and ethylenes as well as some mixtures of these compounds. In addition, certain water chemistry and biological characteristics of the test organisms used, American flagfish and brook trout, were obtained. This information, in conjunction with literature data, will be used to address the following three objectives:

1). Refine and expand the currently established relationships between various molecular descriptors, toxicity test results, and bioconcentration.

2). Develop simple models to take advantage of the relationship between toxicant body burden and toxic responses to predict various toxicity test outcomes and their time course (i.e. kinetics), both for single chemicals and mixtures.

3). Incorporate provisions in the models for accounting for the influence of certain biological and environmental factors on the results.

As it is early in the project the presentation will focus on the current understanding of QSARs in Aquatic Toxicology, how the data set will be used, what outcomes are expected, and their ultimate utility.

B11

ORGANIC CONTAMINANT STRUCTURE PROPERTY TOXICITY RELATIONSHIPS FOR AQUATIC ORGANISMS.

S. Abernethy, D. Mackay*, Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario.

We first describe a novel prediction and correlation procedure by which the acute, and potentially the chronic, narcotic effects of organic chemicals on various aquatic organisms are estimated from a knowledge of the chemical's octanol-water partition coefficient and/or solubility and molar volume. The procedure is based on a hypothesis that acute effects occur when the volume fraction of toxicant at the target site in the organism reaches 0.6%. For chronic effects, the corresponding figure is approximately 0.06%. This total volume fraction may be made up of one of several toxicants.

From a knowledge of the relationship between the target site-water partition coefficient and the octanol-water partition coefficient, the aqueous concentration can be estimated at which pure chemicals or mixtures will cause these defined toxic effects.

The procedure is illustrated using data generated using Ceriodaphnia and other daphnids in our laboratory and reported literature data for other organisms.

It is suggested that the method may be used to estimate the likely narcotic toxic effects of chemicals - pure and mixtures - and to elucidate, from experimental data, when selective toxic effects are present.

B12

TOXICITY OF A TECHNICAL FORMULATION AND PURE PENTACHLOROPHENOL TO THREE SPECIES OF ZOOPLANKTON: LABORATORY (ACUTE/CHRONIC) AND FIELD STUDIES. G.L. Stephenson*, N.K. Kaushik, University of Guelph, Guelph, and K.R. Solomon, Canadian Centre for Toxicology, Guelph, Ontario.

The acute toxicities of a technical formulation of pentachlorophenol (PCP) and pure pentachlorophenol to Daphnia magna, D. pulex and D. galeata mendotae were determined using standardized, laboratory, static, 48h toxicity tests. The 48h-LC_{50} estimates for adult daphnids exposed to pure PCP were 1.80, 5.80 and 0.058 mg PCP/L, respectively. The 48h-LC_{50} estimates for those exposed to the technical formulation of PCP were 2.01, 6.1 and 0.042 mg PCP/L, respectively. The LC_{50} estimates for daphnids exposed to the technical formulation did not differ significantly from those for the pure pentachlorophenol.

The acute toxicity tests were repeated with the pH of test solutions lowered to 5.5 from 7.8 by the addition of sulphuric acid. Exposure to both forms of PCP at the lower pH resulted in decreased 48h-LC_{50} estimates for all three species of daphnia. However, lowering the temperature to 12°C from 20°C did not affect the toxicity of PCP.

Chronic (static with renewal) toxicity tests were conducted with D. magna under conditions comparable to the acute tests. Concentrations ranging from 0.08 to 0.8 mg PCP/L for both formulations did not affect survival or reproduction of exposed individuals.

In situ enclosures were used to expose natural populations of zooplankton from a mesotrophic lake to a nominal concentration of 1.0 mg pure PCP/L. The results of this field study will be discussed with respect to predictions based on the laboratory testing.

B13

ULTRAVIOLET DISINFECTION: ITS EFFECT ON ESCHERICHIA COLI AND BACTERIOPHAGES AS INDICATORS OF DISINFECTION EFFICIENCY OF WASTEWATER. G. A. Palmateer (1) and *G. E. Whitby (2) (1) Ministry of the Environment, Southwestern Region, London, Ontario, (2) Trojan Technologies Inc., London, Ontario.

The significance of photoreactivation of ultraviolet (UV) irradiated E. coli was studied in situ during the disinfection of wastewater. To evaluate the response of E. coli to UV light, the level of nalidixic acid resistant E. coli (NAR) in wastewater was monitored in the outfall and for a two hour period downstream following UV irradiation. Bottles containing E. coli (NAR) and indigenous E. coli underwent photoreactivation in glass bottles. E. coli (NAR) declined in the receiving stream to a barely detectable level during two hours of flow downstream. Control runs showed no significant difference in the decline rate of E. coli (NAR) which were not irradiated. Photoreactivation is likely of limited concern when designing UV wastewater disinfection devices.

Two methods were used to determine the suitability of bacteriophage as indicators of UV disinfection efficiency. A filtration method and a most probable number procedure were used to monitor the level of F+ specific RNA and DNA, somatic RNA bacteriophage and coliphage. Results indicated that the bacteriophage and coliphage were as sensitive to UV disinfection as E. coli, fecal coliforms, fecal streptococci and Pseudomonas aeruginosa. Exposure of the bacteriophage to sunlight did not initiate photoreactivation as the levels of bacteriophage remained unchanged. Approximately ninety times more F+ specific bacteriophage were recovered from chlorinated wastewater than from UV irradiated wastewater. Using present methods, bacteriophage are no more effective than typical bacterial indicators of disinfection efficiency.

B14

LABORATORY TESTING OF A HYDROCYCLONE FOR PRIMARY CLARIFICATION

BY JOHN D. BOADWAY
DEPARTMENT OF CIVIL ENGINEERING, QUEEN'S UNIVERSITY

A special hydrocyclone has been designed and built for efficient grit removal and as a partial method of primary clarification. Whereas the initial intention was to test it in a sewage treatment plant this was not done due to a reorganization of the Ministry and pilot plant studies were done instead. Initial laboratory tests had shown it to be extremely efficient in removing fine screen sizes of grit and sawdust. Further laboratory testing has now been done to define its separation capability in removing slow settling inorganic solids, to examine the type and quantity of organic particle it would remove from primary sewage and to assess its capability in removing known sewage contaminants from mixtures.

B15 THE EVALUATION OF NATIVE MARSH PLANT SPECIES FOR THE TREATMENT OF DOMESTIC SEWAGE. J. Neil, J. Graham, Limnos Limited, 591 Liverpool Road, Pickering. Ontario L1W 1R1.

Research is presently underway to compare the efficiency of three aquatic plant species for their ability to treat domestic sewage in an artificial marsh environment. The species being evaluated are: Typha angustifolia (narrow leaf cattail), Scripus validus (bulrush) and Phragmites australis (common reed). T. angustifolia has been evaluated in a full scale marsh treatment system at Port Perry, Ontario. The other two species, S. validus and P. australis have not been evaluated in Canada and little use of them has been made elsewhere for wastewater treatment.

Monoculutre stands of each species have been established in separate steel enclosures. Each cell measures 15m x 1.5m, providing a length to width ratio of 10:1. Until May, 1987, pre-treated sewage of a known quality was applied to each cell. Currently, a mix of raw sewage and partially treated lagoon effluent is being used as influent for the experimental facility. The effluent from each cell will be sampled bi-weekly until the end of October, 1987. Standard wastewater parameters including D.O., BOD, S.S., H2S, TP and TN will be measured.

A fourth cell providing a control has been converted to serve as a duckweed (Family:Lemnaceae) polishing cell as of July, 1987. Effluent from the Typha cell will be used as influent for the duckweed polishing cell. The primary objective of this additional study is to determine if ammonia can be removed for the Typha cell effluent by prescribed harvest of the duckweed. Additional reduction of BOD, S.S. and TP may also be achieved by the use of the duckweed polising cell.

Sampling of the facility has been continuous since August, 1986 except for a period in the winter of 1987 when total freeze up of the facility occurred. Results obtained will be compared to the adjacent, full-scale operating cattail marsh and design criteria developed for scale-up of successful species.

B16 | A DEMONSTRATION STUDY FOR BIOLOGICAL PHOSPHORUS REMOVAL AT LAKEVIEW WPCP.

Michael Yue* and Vijay Thadani, Gore & Storrie Ltd., Toronto, Ontario - Gerry Healey, Lakeview WPCP, Mississauga, Ontario.

A three phase demonstration study, funded by the Ministry of the Environment, is being undertaken at the Lakeview WPCP to assess the phoredox process as a method of biological phosphorus removal and the effect of the process on solids handling and plant operation. Phase 1 and 2 of the study are complete, while Phase 3 is scheduled for completion in fall of 1987.

The demonstration is being conducted in the first expansion module of the plant which consists of two equally sized trains of aerationand final tanks and a common return sludge facility. One train is used as a test train and the other as a control unit. Currently, a ferric chloride solution is added to the end of the aeration tanks to effect phosphorus precipitation.

Phase 1 demonstration was an operation of the test train without chemical addition to purge the residual iron from the system and provide a sludge for biological phosphorus removal. Phase 2 involved the introduction of an anoxic zone in the first pass of the test train aeration tank. It examined the effect of minimum air supply on the removal of phosphorus and system operation. The results indicated that the test train could achieve approximately 60% chemical reduction and produce similar good quality effluent but required a longer period to recover from shock loads. Phase 3 involves the introduction of an anaerobic zone in the test train aeration tank. Preliminary results indicate that the test train can produce an effluent of less than 1 mg/l P without chemical addition and is not affected by routine shock loads.

B17 OPTSTOR COMPUTER PROGRAM FOR COST-EFFECTIVE STORAGE IN SEWER SYSTEMS. Sheldon H. Zemell,* MacLaren Plansearch Inc., Toronto, and Rob Bishop, Marshall Macklin Monaghan Limited, Toronto.

Nearly ten years ago, OPTSTOR was originally developed by MacLaren as a tool for determining cost-effective locations and volumes for storage in a surcharged sewer system. In the current project begun at the start of this year, OPTSTOR has been upgraded significantly in several respects. The program has been generalized to include not only local off-line storage, but also trunk off-line, trunk in-line and local in-line storage. In addition, the efficiency, user interface and program documentation have been markedly improved.

OPTSTOR is used together with the U.S. EPA SWMM model. The RUNOFF module of SWMM serves to generate estimates of inflows, while the EXTRAN module simulates the time-dependent hydraulic status of the system to provide the downstream head. Then, the steady-state OPTSTOR program is applied to individual lines within the network to determine storage requirements.

In OPTSTOR, hydraulic losses are described by the Manning formula (as in EXTRAN). For each of the four types of storage considered, curves relating the volume required for any given percentage reduction in peak flow have been derived and are embedded in the program. The cost is taken to be a quadratic function of storage volume.

The minimization of storage costs is achieved by means of the so-called Complex Method due to M.J. Box. An initial complex of random feasible solutions is obtained by a trial-and-error procedure. Then, these are improved by means of reflections of the current maximum-cost solution about the centroid of the remaining solutions.

OPTSTOR has a free-format input and runs on either a VAX or IBM PC. The program's methodology, assumptions and application to a demonstration system are discussed.

B18

TOWNSHIP OF IGNACE, VYREDOX TREATMENT PLANT FOR A GROUNDWATER SUPPLY. D.R. Turnbull* Vice-President, J.A. Harris, Project Engineer, International Water Supply, Ltd., Box 310, Barrie, Ontario.

Recent studies by IWS Ltd. in conjunction with the M.O.E. indicated raw water problems were related to the presence of iron manganese, hydrogen sulphide and dissolved organics in the groundwater. The chemical and biological activity in the distribution system resulted in an accumulation of biological debris which created a health hazard and user complaints of taste and odour.

Field and Laboratory analysis of raw groundwater samples indicated an in-situ Vyredox chemical/biological method would treat the raw water by altering conditions in the aquifer. Subsequent pilot plant studies confirmed the Vyredox method reduced the iron from 3.5 to 0.14 mg/litre and the manganese from 0.47 to 0.22 mg/litre.

Final design of Vyredox treatment plants at No. 1 and No. 2 Wells with a total capacity of 76 litres/second was based on a detailed hydrogeochemical and stratigraphic logging of a series of test wells adjacent to the production wells.

The study reviews preliminary results from the "run-in" period for the Vyredox method and evaluates the environmental and economic advantages of the "in-situ" treatment of the aquifer.

BP1 EXTRACTION & CONCENTRATION METHOD FOR TESTING OF LANDFILL LEACHATES. Jack Brady,* Art Horton, G. Thomas, Ontario Research Foundation, Mississauga, Ont.

The objective of the study is to develop methods based on the Ames Salmonella mutagenicity assay to detect potentially harmful contamination of groundwater supplies by genotoxic substances leached from landfill sites.

A select list of chemicals (including suspected/known mutagens) which exhibit different functional group features as well as representing a wide range of chemical and physical properties has been compiled. These chemicals were initially tested in the Ames bioassay to determine individual and combination responses in order to evaluate if their mutagenic activity was additive and how the different mutagens (direct and indirect acting) behave in combination. At the levels expected to be encountered for mutagenicity testing toxicity to the tester strain was not a problem. These chemicals are being used to develop and validate methods for the collection of organic concentrates from groundwater in order to provide material suitable for use in the Ames bioassay. The concentration methods are based on accumulator columns (resin adsorption), and purge and trap techniques.

This paper will present an evaluation of the effect of parameters such as cartridge dimensions, adsorbent (type and mesh size), flow rates through the cartridge and desorption methods on the overall recovery of specified target compounds from groundwater. Similarly, parameters such as water volume, purge flow rates, purge times and compound collection (adsorbent or cryogenic trapping) on the recovery of target compounds will be addressed.

BP2

THE APPLICATION OF A FUGACITY MODEL TO MUNICIPAL WASTEWATER TREATMENT by L. Tasfi, D. Mackay, B. Clark, G. Henry, Environmental Engineering Program, University of Toronto, Toronto, Ontario.

To improve the removal of organic chemicals in biological wastewater plants a better understanding of the fate of these chemicals during treatment and how their physical parameters and plant operating conditions influence their behaviour is needed. A model based on the fugacity modelling concept has been developed to predict the fate of synthetic organic chemicals in a biological wastewater treatment plant, using as input the physical properties of the chemical and the relevant operating parameters of the treatment plant. The removal mechanisms of volatilization, stripping, biodegradation, and sludge wasting are considered in the development of the model.

Results show that the most important physical properties of the organic chemicals affecting their fate in a sewage treatment plant are the octanol-water partition coefficient, Henry's Law constant, and the biodegradation rate constant. The effects of different plant operating parameters, such as sludge age, aeration rate, and sludge wasting on the removal of organic chemicals are also evaluated. If the sludge age is reduced below 3 days, thus inhibiting the biodegradation of organic chemicals, then other processes become more significant, and the octanol-water partition coefficient and Henry's Law constant determine whether the organic chemical is stripped during aeration, volatilized during sedimentation, or sorbed to sludge during primary and secondary treatment. However, if the sludge age is longer than 3 days, biodegradation may significantly change the fate of the synthetic organics.

The model proved to be effective in predicting the fate of organic chemicals and their concentration in the plant effluent, aeration off-gases, and in waste sludges. It may be useful for improving the performance of existing plants, or to select design parameters for new plants.

BP3

MULTIMEDIA ENVIRONMENTAL AND HUMAN EXPOSURE ASSESSMENT OF ORGANIC CONTAMINANTS. D. Mackay* and S. Paterson, Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario.

A multimedia model of the environmental fate and behaviour of organic chemicals is described. It is a modified steady state fugacity-based model which incorporates expressions for additional non-diffusive processes of wet and dry particulate deposition, rain washout, sediment resuspension, and leaching from soil.

An unsteady state version has also been developed.

The models are applied to selected chemicals in Southern Ontario which are of concern to the Ministry. The extent to which they yield environmental concentrations and general behaviour characteristics in agreement with observations is discussed.

The models are extended to predict concentrations in meat, milk, and vegetation and to quantify human exposure by routes of air inhalation and food and water ingestion.

The human exposure results are used as input for a recently developed pharmacokinetic model to determine human physiological tissue distribution. The set of models provides a comprehensive picture of the pathways of a contaminant.

BP4

CLAM BIOMONITORING: EFFECTS OF TEMPERATURE AND PROCEDURAL VARIATIONS ON CONTAMINANT UPTAKE WITH NOTES ON THE DISTRIBUTION OF ALTERNATE SOURCES. Al Melkic*, Tim Smith and Karen Kowalchuk, Integrated Explorations, P.O. Box 1385, Guelph, Ont. N1H 6N8.

The use of clams for the detection of trace contaminants is well recognized by the Ontario Ministry of the Environment. The method has proved useful in elucidating the presence of contaminants in municipal and industrial outfalls.

Elliptio complanata is the species most commonly used. Currently stocks of E. complanata are procured from Balsam Lake in southern Ontario. A survey of 52 locations on 24 lakes and associated water bodies in the Muskoka, Haliburton and Kawartha Lakes regions was undertaken in an attempt to identify alternate, uncontaminated sources of E. complanata and other clam species which could be utilized as potential biomonitors. The results and findings of this survey will be presented.

Clam biomonitoring methodologies, to date, have typically ignored the possible effects of such variables as temperature and procedural variations in transportation of live clams, deployment and preservation of clam tissues prior to processing. A series of in situ experiments were designed and implemented in an effort to assess the effects, if any, of these physical parameters on the uptake of PCB's by E. complanata obtained from Balsam Lake and exposed to Niagara River water for a standard 21 day period. Analytical procedures followed those outlined by the Ontario Ministry of the Environment protocol for the determination of PCB's in fish tissues.

BP5 A METHOD FOR PREVENTION AND MITIGATION OF NUISANCE BLUE-GREEN BLOOMS IN EUTROPHIC WATERS IN ONTARIO. B.A.R. Environmental and Anthony Usher Planning Consultant, Toronto, Ontario.

Blue-green algae blooms are a problem in eutrophic Heart Lake although their relative abundance has decreased since initiation of aeration in 1975. During the summer of 1986, large changes in the relative abundance of blue-green algae occurred despite high, constant DIC and high concentrations of dissolved P and N. Relative abundance did not appear to be related to temperature or light. However, relative abundance was inversely related to one of the components of DIC, $H_2CO_3^*$ (CO_2 aqueous + H_2CO_3), with low concentration near atmospheric equilibrium favoring blue-green algae and high concentrations 5-6 x atmospheric equilibrium favoring eucaryotic algae. $H_2CO_3^*$ was always less than 4% of DIC. Reported relationship between blue-green dominance and temperature, anoxic bottom waters, CO_2 depletion, low N/P ratios and nitrate depletion probably have a common link; highly reduced sediments. Since $H_2CO_3^*$ is controlled by the partial pressure of CO_2 and not DIC, pH or alkalinity, aerobic microbial respiration is seen as a key factor in elevating $H_2CO_3^*$ concentrations above atmospheric equilibrium and reducing blue-green algae blooms.

The social and economic benefits of mitigating nuisance blue-green algae in small lakes and impoundments in southern Ontario were investigated to help decide whether other research opportunities should be pursued. Blue-green algae impacts on recreational use and management and their economic and social implications were assessed for five Conservation Authority recreational areas on the basis of discussion with management staff. While net losses to users and management agencies are small at a provincial scale, they are locally important, especially because there are few nearby alternatives to many of the affected sites. Continued efforts to identify improved mitigation techniques are therefore justifiable.

BP6

REMOTE SENSING DETERMINATIONS OF NORTH-EASTERN ONTARIO LAKE CHARACTERISTICS. J. Roger Pitblado,* Geography Department, Laurentian University, Sudbury, Ontario P3E 2C6

This remote sensing project was designed to examine the feasibility of using remotely sensed data for the determination of surface water quality characteristics of lakes in Northeastern Ontario, with a special focus on discriminating between acidified and non-acidified lakes. Further, the project involved the comparison of a selected number of sensors to undertake such tasks.

Based on the results of this project as well as those that can be found in the literature, it is clear that several water parameters can be predicted with confidence using satellite or airborne sensor data. This is particularly evident for Secchi disk depth and dissolved organic carbon. Chlorophyll a and other water quality indicators are much more difficult to determine except in the form of general categories. Similarly, in the Sudbury area remote sensing data can be employed to discriminate gross differences: acidic/non-acidic; low/high trophic status.

The ability to estimate lake characteristics, using multiple regression models and image analysis techniques, improves dramatically with increases in the spatial and spectral resolution (especially the latter) of the remote sensing data. This is seen as one moves from Landsat MSS, to Landsat TM, to airborne sensor data.

BP7

ROBUST TREND ASSESSMENT OF WATER QUALITY TIME SERIES. Byron Bodo, Ontario Ministry of the Environment; Keith W. Hipel*, Dept. of Systems Design Engineering, University of Waterloo; A. Ian McLeod, Dept. of Statistical and Actuarial Sciences, The University of Western Ontario.

Trend analysis of water quality time series is often complicated by non-normal data, uneven time spacing, seasonality and non-monotonic trend. A graphically-oriented methodology which is robust against these confounding factors, is described for decomposing river quality time series into trend, seasonal and residual noise components. Trends are defined via Cleveland's robust locally weighted regression [RLWR] procedure. Low powered RLWR reveals the presence of pronounced seasonal cycles, abrupt jumps such as caused by point source removal and short term trends. High powered RLWR is used to characterize medium and long term trend. A robust seasonal function is determined empirically as the moving seasonal median of the aggregate historical record. Trend and seasonal components are separated by iterative algorithms which yield: 1. deseasonalized trends for highlighting short and medium term departures from historical seasonal norms, 2. seasonally adjusted trends for identifying long term shifts in mean levels, 3. trend adjusted seasonal norms which are historical seasonal variations adjusted to current mean levels when significant trends have occurred. Illustrative applications to historical temperature, DO, BOD, and chloride data series from Ontario's Don River demonstrate the power of the methodology.

BP8 REPRODUCTIVE OUTCOMES IN SOUTHWESTERN ONTARIO, 1980 to 1985. J. McD. Robertson,* H. J. Chan, I. M. Fyfe, Epidemiology & Biostatistics, The University of Western Ontario, London, Ontario, N6A 5C1

The aim of this study is to determine if an association exists between consumption of drinking water from the St. Clair River and abnormal outcomes of pregnancy and adverse first-year-of-life outcomes in Kent and Lambton Counties in the period, 1980 through 1985. The total incidence rates of congenital anomaly, low birth weight, and infant death in the two counties were similar to those of the Ontario Southwest Region and the Province. The rates of spontaneous abortion in Kent County and in the "exposed" and "nonexposed" subgroups were significantly higher (RR = 1.4 to 1.7). The "exposed" subgroup in Kent County had a significantly low rate of stillbirth (RR = 0.40); whereas the rate for the county was similar to those of the comparison groups. The rate of spontaneous abortion in Lambton County was significantly low (RR = 0.55) These results did not support an association between drinking water from the St. Clair River and the outcomes of interest. The second phase of the study consists of interviewing the 490 women who experienced 666 abnormal outcomes in the period of study and a control group of women who had normal children to determine their exposures to St. Clair River water during the index pregnancies. As of 31 July, 1987 we had contacted 261 women, 237 (91%) of whom agreed to be interviewed. In the third phase of the study the outcomes of pregnancies in a cohort of women who were exposed to drinking water from the St. Clair River at the time of five specific chemical spills will be compared with those of three nonexposed cohorts. In the fourth phase we shall compare the outcomes of all pregnancies that occurred among Native women of the Walpole Island Reserve with those of women of the Sarnia Reserve; a direct comparison between a heavily exposed and a virtually nonexposed population.

BP9

REGIONAL ANALYSIS OF LOW FLOW CHARACTERISTICS. H.S. Belore* and D. Ashfield, Cumming Cockburn Limited, 145 Sparks Avenue, Willowdale, Ontario.

This project is supported by the Ministry of the Environment through the River Systems Unit.

When undertaking environmental investigations related to watercourses, the knowledge of hydrologic conditions which exist during low flow conditions can be of primary importance. The identification of suitable low flow characteristics within a watercourse is most easily accomplished using continuous hydrometric data recorded for the stream. However, this is limited to the availability of suitable long term discharge records at the location of interest. The objective of this investigation is to develop a practically oriented technique for estimating low flow characteristics at ungauged locations in the Province.

First, the background review will confirm the most appropriate regionalization technique. Then low flow characteristics such as flow duration curves and extreme values for various durations and frequencies, will be determined for selected stations in a test area in Southwestern Ontario. Watershed parameters to be used in the prediction equations will then be determined for selected drainage basins in the test area. The selected regionalization methodology will then be applied and the method evaluated in the test area to confirm the usefulness in predicting low flow characteristics based on meteorolgical and physiographic characteristics of ungauged watersheds.

Finally, the results of the single station low flow analyses together with a summary of regional characteristics will be summarized in a map format. The latter will update the map series entitled, "Low Flow Characteristics", previously published by the Ministry of Environment.

BP10

ASSESSMENT OF ALTERNATIVE WATER TREATMENT PROCESSES ON NORTHERN ONTARIO WATER. Stuart J. Wyse and David R. Fisher, Proctor & Redfern Ltd., 45 Green Belt Drive, Don Mills, Ontario.

This study, supported entirely by the Ontario Ministry of the Environment, was designed to assess the best water treatment process and treatment chemicals for the water supply to the Town of Kirkland Lake and adjacent communities. The raw water is not entirely typical for the area but it is anticipated that the results will be applicable to other communities in Northern Ontario.

Three technologies were assessed. Firstly a plate flocculator/plate separator technique and conventional dual media filter which had not been utilized for drinking water treatment in Ontario. Secondly a high rate upflow clarifier followed by a multi-media downflow filter which has had very limited use in Ontario. Finally a mechanical flocculator/plate separator more conventional system with dual media filter.

Various coagulants and coagulant aids were assessed on each of the three process systems in order to optimize chemical effectiveness.

BP11 SLOW SAND FILTRATION FOR DRINKING WATER PRODUCTION IN SMALL NORTHERN COMMUNITIES. W.J. Hargrave*, Anita Loucks, Gore & Storrie Limited, Toronto, Ontario.

This study, supported by the Ministry of the Environment, is designed to investigate the design, operation, and maintenance of slow sand filters. More specifically, new design methods will be developed to allow more versatility in the application of slow sand filtration. In the past, design guidelines for slow sand filters have been very restrictive and do not allow for optimization of a system. This study will examine a range of possibilities to enable the design of a facility which suits the specific needs of the community. The design data will be put in a form that will permit optimization of the design for specific site conditions. This study will also investigate the following: (1) Simple methods of alum addition for colour removal; (2) the effect of pre-treatment, raw water conditions, filtration velocities, filter media sizes and depths, and depth of water over the media on the operation of slow sand filters; (3) the effect of climate and the protection required to prevent freezing; and (4) capital and operating costs.

BP12

LOCATING AREAS OF GROUNDWATER FLOW TO SURFACE WATER. David R. Lee*, AECL, Chalk River, Ontario; Wayne C. Wager*, Ontario Ministry of the Environment, Sarnia; Peter B. Kauss, Ontario Ministry of the Environment, Toronto.

Landfill sites, both active and abandoned, mine-tailing areas and major industrial complexes have frequently been located adjacent to surface waters primarily because of transportation and process water needs of industry. While leachate plumes and attenuation zones of inland disposal sites have frequently been assessed, methods for assessing subsurface discharges directly to surface waters are largely lacking.

In summer of 1986, work was initiated in the Upper Great Lakes Connecting Channels (St. Clair and St. Marys Rivers) using a rugged sediment probe to target areas of river sediment where temperature and conductivity differed from background suggesting groundwater discharge. In this method the probe was towed along the bottom behind a slowly moving boat.

Follow-up work conducted in the St. Marys River during the summer of 1987, supports the efficiency of the method to target leachate flow areas from river sediments into surface waters.

BP13 AN EXAMINATION OF CHRONIC TOXICITY OF THIOCYANATE TO FRESHWATER FISH FOR THE DEVELOPMENT OF WATER QUALITY CRITERION. D.G. Dixon, R.P. Lanno and S.D. Kevan, Dept. of Biology, University of Waterloo, Waterloo, Ontario.

The aim of this research is to obtain sufficient data on the chronic toxicity of waterborne thiocyanate (SCN) to establish a water quality criterion. Juvenile rainbow trout will be exposed to sublethal levels of SCN for four months and effects on growth, plasma cyanide (CN),SCN and thyroid hormone levels, and liver glycogen and liver protein levels will be monitored. Liver, kidney, gill, thyroid and gonads will be subjected to histological examination. A second study will expose fathead minnows to sublethal levels of SCN for an entire life cycle to assess the effects of SCN on reproductive performance. We also propose to examine the toxicity of short-term pulse-exposure of fish and eggs to SCN, an exposure protocol more appropriate to the management of mixing zones and spills. Finally, we propose to apply some of the biochemical and histological indicators of SCN toxicity derived from our laboratory studies to the assessment of SCN impact on a feral fish population in the Hemlo mining region of the White River drainage basin in Northern Ontario.

BP14

BIOMONITORING PROTOCOLS FOR ADULT AQUATIC INSECTS: COLLECTION PROCEDURES, SEASONAL VARIATION AND DISPERSAL. Zsolt E. Kovats, Jan J.H. Ciborowski* and Stephen Pernal, Dept. of Biological Sciences, University of Windsor, Windsor, Ontario, N9B 3P4.

Benthic aquatic insects living in contaminated sediments can carry high organochlorine burdens. But their value as bio-monitors can be limited by difficulties of sampling and of collecting enough biomass for analysis by gas chromatography (GC) (typically 5 g fresh wt.). Collection of the nocturnal, photophilic, winged adult stages is potentially simpler and less expensive. Our objectives were to a) develop traps to collect sufficient adults to permit GC analysis for organochlorine contaminants (PCBs, HCB, OCS, QCB); b) determine minimum sample biomass that provides reasonable limits of detection; c) assess seasonal insect availability and variations in contaminant burden; and d) evaluate dispersal abilities to estimate size of area to which a sample collection pertains. We used 12V/DC battery-powered C.D.C.-type ultraviolet light traps. CO_2 subliming from dry ice in the trap base (1 kg h^{-1}) quickly killed trapped animals. Although Trichoptera (Hydropsychidae, Leptoceridae) actively entered traps, Ephemeroptera (Hexagenia, Caenis) alighted nearby and required hand-collection. Weekly samples were taken during 2 h following sunset at Detroit R. and St. Clair R. sites beginning in early May. Adequate biomass was collected in single traps on 26 May. Thereafter, animals were abundant at sunset temperature >19° C. and wind speed <10 km h^{-1}. Mean ($\pm$1 S.E.) June Trichoptera catch was 86.5$\pm$44.9 g/2 h/trap (N=6). Hexagenia biomass varied greatly among sites and dates (range 20 - 605 g/2 h/trap, where present). Mid-June samples at uncontaminated sites provided Hydropsychidae (Fenelon Falls, 285 g) and Hexagenia (Balsam Lake, 70 g) for detection limit studies. Traps up to 5 km inland were monitored on calm, warm evenings to estimate dispersal distance. Hexagenia numbers were relatively constant up to 3 km from L. St. Clair. Few animals were caught beyond this distance. Catches of L. St. Clair Hydropsychidae were more variable.

BP15

USER'S MANUAL FOR RIVER MIXING ZONE ANALYSIS PROGRAMS. T.P. Halappa Gowda and Rob Jarvis, Gore & Storrie Ltd.

The user's manual describes the calibration and application of a personal computer package to predict spatial concentration distributions in the mixing zones of shallow rivers receiving point and diffuser discharges. The model is based on the two-dimensional convective dispersion equation. It utilizes the stream tube co-ordinate transform concept developed by Yotsukura and Cobb (1972) and modifications to account for longitudinal variabilities in decay rate coefficients and hydraulic parameters of river channels (Gowda, 1980).

The computer package is set up in an interactive (enquiry/response) mode. The required site-specific input data are described. The package also predicts the critical points in any river transect where the Provincial water quality objectives are achieved. The outputs include many computer graphics options to assist the user. Detailed technical discussions of the various package components are presented in the appendices.

RP16 A CONVENIENT AND ACCURATE "MACRO" PROGRAMME FOR THE QUANTIFICATION OF PCBs IN ENVIRONMENTAL SAMPLES. I.D. Brindle and C.L. MacLauren, Chemistry Department, Brock University, St. Catherines, Ontario L2S 3A1.

Quantification of PCBs by GC/ECD is made difficult because of the large number of congeners present in any Aroclor or mixture of Aroclors. This programme, for the Hewlett-Packard 5895 workstation, takes the response of eighteen peaks from the chromatogram and determines an average response. The response in updated for each calibration standard. Problems with interferences from other compounds that elute at the same time are dealt with by allowing a comparison of integrated area ratios. Values for these ratios that fall outside a specified window are flagged so that misassignment is reduced. The calibration curve is linear with a non-zero intercept and allows satisfactory determination of PCBs to around 20 ppb.

BP17

THE EFFECTS OF RURAL AND SUBURBAN DEVELOPMENT ON SURFACE WATER QUALITY IN FIVE SELECTED SUBWATERSHEDS ON THE UPPER HUMBER RIVER, 1986. Richard Hubbard*, Brian Hindley, Metropolitan Toronto and Region Conservation Authority, North York, Ontario.

Previous research on the Upper Humber River indicated a combination of diffuse and point-source inputs were responsible for the observed widespread water quality degradation. The present study was conducted to assess in greater detail the relative pollutant contributions from five of the most predominant land used types within the watershed: suburban construction, agricultural row crops, livestock access, streambank erosion and undisturbed forest. The five study subwatersheds, ranging in size from 2.6 to 21.9ha were all located in the northwestern portion of the Humber River watershed. Surface water samples, under dry, wet and spring melt conditions, were collected at stations immediately upstream and downstream of each land use area, eliminating as much as possible any extraneous inputs. Bed sediment and soil samples were also collected on occasion and bed load samplers and off-stream sediment traps were installed. Preliminary results indicate severe microbiological pollution occurring through the livestock subwatershed under all weather conditions. With one exception, fecal coliform densities ranged from approximately 200 to >500,000 counts/100ml during dry weather and FC concentrations in downstream bed sediments exceeded 4500 counts/gm sediment. Surprisingly high FC concentrations were also noted within the heavily forested "Control" subwatershed; possible sources are suggested. Concentrations of chemical parameters generally appeared low within all subwatersheds under dry weather conditions. Spring melt and wet weather data are currently being analysed. On the basis of hydrologic and precipitation data, annual parameter loadings are estimated for each study subwatershed and the results generalized to the entire Upper Humber River basin.

BP18

AN ECOSYSTEM APPROACH TO MONITORING PCB's IN PRISTINE ONTARIO LAKES. C.D. Metcalfe and C.R. Macdonald, Trent University, Peterborough, Ontairo.

In an ongoing study, concentrations of PCB's and organochlorine insecticides are being monitored in 8 lakes within Peterborough, Haliburton, and cumulation of these compounds, and the relative importance of atmospheric deposition of these contaminants into relatively pristine lakes. Study lakes were chosen to include both relatively eutrophic and obligotrophic lakes, with a "gradient" of PCB concentrations in upper trophic levels in the lakes which ranged from "contaminated" (high ppm levels) to "uncontaminated" (low ppb levels). Water, suspended particulates, zooplankton, bottom sediments, benthos, and 5 fish species were analyzed from each lake. Chemical analyses were done by congener-specific capillary column gas chromatorgraphy.

Preliminary data analyses indicate that PCB concentrations vary by at least 3 orders of magnitude through the various compartments of the lake ecosystems and the distribution of PCB congeners shifts to higher chlorinated compounds in upper trophic levels. Lake trout always accumulate the highest crayfish, anodontid clams, and zooplankton are also good indicators of the degree of PCB contamination.

Lake Clear in Renfrew County,is a heavily PCB-contaminated lake, which is being used as a model system for PCB transport studies. This lake is unique among the study lakes in having a relatively uniform PCB congener pattern among all compartments of the ecosystem. EXAMS and WASTOX aquatic contaminant models will be used to estimate total PCB loading into Lake Clear, and to predict the distribution of selected PCB congeners in the various ecosytem compartments. The suitablity of these models in describing the distribution of PCB's in pristine lakes is being evaluated by comparing model estimates to actual analysis data from Lake Clear.

C1 WASTE REDUCTION STRATEGIES FOR CALIFORNIA'S PRINTED CIRCUIT BOARD INDUSTRY : RESULTS OF A STUDY AND TECHNOLOGY DEMONSTRATION PROGRAM AND POTENTIAL APPLICATION TO ONTARIO'S HEAVY METAL GENERATING INDUSTRIES. B. Fleet*, Dept of Chemistry, University of Toronto, C. Small, SCADA Systems, Toronto, R. L. Judd, CAl-Tech Management Associates, Sacramento, G. A. Davis, University of Tennessee, B. Piasecki, Clarkson University, and M. Mueller, Clarkson University, Potsdam, NY.

A recent study (1) carried out by the above authors has reviewed the various technologies and strategies for handling the toxic waste streams generated by California's Printed Circuit Board Industry. With its strict environmental enforcement climate and strong opposition to land disposal of toxic wastes, the California situation serves as a useful model for other regions environmental waste management strategies. The study has focused on approached for treating toxic metal wastes including copper, nickel, lead and tin and has compared the advantages of conventional chemical "sludge" treatment with a range of resource recovery and recycling technologies such as ion-exchange and electrolytic recovery(2).

In addition three case studies have been carried out, reviewing current waste management practices in three plants of different sizes and types of manufacturing operation. One objective of the case studies was to examine the effect of various factors including type of plant, current waste management system and practices, the local environmental regulations and waste disposal costs, etc., on selection of the optimal waste management strategy.

A second phase of the project was recently awarded and comprises the design, construction, commissioning and performance evaluation of a zero-sludge waste reduction system at a major southern California Printed Circuit Board plant (3).

This paper will review the major findings of the above study and technology demonstration and attempt to indicate the transferability of the findings to other heavy metal pollution generation industries of importance to the Ontario economy including metal finishing, semiconductor manufacturing and gold mining. The relevance of some of the data to a recently awarded MOE study (4) on economic factors influencing heavy metal resource recovery waste management strategies will also be examined.

C2 EXPERIMENTS ON THE MOVEMENT OF IMMISCIBLE LIQUIDS AND THEIR VAPOURS IN SOIL. G. Farquhar*, W. Abbott, R. Kell, E. McBean and B. Stickney, Department of Civil Engineering, University of Waterloo, Waterloo, Ontario, N2L 3G1, Canada.

An experimental programme to study the movement of immiscible liquids and their vapours in soil has been in progress over the last three years. This paper presents current results from the study. The movement of four immiscible liquids in sandy soils has been examined with the use of laboratory scale columns. Separate measurements of capillary pressure and relative permeability were made and used with a transport model to simulate immiscible liquid movement. Two dimensional experiments to investigate fingered flow in stratified media were also performed.

Vapour movement was examined from two types of liquid sources, one a flat pool at the water table and the other a suspension in pores in the unsaturated zone. A two dimensional chamber chamber filled with sandy soil was used for these experiments. A vapour transport model provided successful simulations of the vapour movement. The results are evaluated in the context of assessing and controlling hazardous immiscible liquids and their vapours resulting from spills and leakages into soil.

C3 HAZARDOUS ORGANIC CHEMICALS IN GROUNDWATER AT ONTARIO LANDFILLS. James F. Barker*, John A. Cherry, Donald A. Carey, and Michel E. Muttes, Institute For Groundwater Research, Dept. of Earth Sciences, University of Waterloo, Waterloo, Ontario.

The occurrence and mobility of organic contaminants in groundwater has been evaluated at seven sites in Ontario. An overview of the results will be presented. Two sites on Canada Forces Base Borden will be discussed more extensively.

The "Borden" site is situated upon an unconfined sand aquifer. It was operated from about 1940 to 1973, receiving mainly construction debris and some domestic and commercial wastes which were periodically burned. The "New Borden" landfill site has been operated since 1976. It is situated upon less permeable silty sand till. The waste is landfilled in cells without burning. Although an extensive inorganic plume eminates from the Borden landfill, very little organic material is found in this plume. This probably reflects the nature of the landfilled material and the periodic burning of the refuse.

A much less extensive plume eminates from the New Borden landfill site, reflecting the lower groundwater velocity. Numerous organics of concern have been recognized in this plume, including chlorinated hydrocarbons, and aromatic hydrocarbons. Sorptive retardation does not seem to provide a major control on the organic mobility. Biotransformations seem to be the major attenuating process. Interpretations are complicated, however, by the temporal variability of both leachate character and organic contaminant distributions in the plume.

C4

NATURE OF SUBSTRATES IN INDUSTRIAL WASTES RELATIVE TO ELEMENTAL LEACHABILITY James R. Kramer*, J. Gleed, O. Mudroch, P. Brassard, P. Collins. Dept. of Geology, McMaster University, Hamilton, Ontario L8S 4M1.

A chemical sequential extraction procedure (CSEP) has been developed to determine the mobility and potential toxicity of metals in wastes under various chemical environmental conditions (e.g. acidity, redox). Results of the CSEP were compared to those obtained from the O.M.E. provisional "Leaching and Toxicity Test" for various kinds of industrial wastes; the O.M.E. provisional test is a step-wise adjusted mild acid extraction routine. The study shows that the first two steps of the CSEP (ion exchange and mild acid), under both oxidizing and reducing conditions, predict readily mobile metals. In some cases, these tests are more sensitive for metal mobility than the O.M.E. provisional test. The repeatability of the tests are between 10-20% which is quite sufficient to differentiate between a mobile and a bound element; metals tend to be differentially concentrated by factors of 5-100+ times in the different extraction steps. There can result a large difference in results for dry and damp samples of the same waste. The same type (smelter, iron/steel, sewage, plating etc.) of waste tends to display similar metal mobility. There are other artifacts displayed in both the CSEP and OME tests, resulting mostly from the variable "buffer" effect of the waste material itself. An automated kinetic procedure, incorporating the best features of the O.M.E. provisional and sequential extraction tests is proposed as a more rigorous test of actual metal mobility. Comparison of the automated kinetic, CSEP and provisional O.M.E. tests are made, emphasizing cases where differences in results are obtained. Finally a protocol is proposed for the assessment of the mobility of metals in wastes.

C5 REPORT ON THE STUDY OF CODISPOSAL OF MUNICIPAL AND SOLID INDUSTRIAL WASTES. Donald Kirk and Salim Pirani*, Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario.

This study, supported by the Ministry of the Environment, was designed to determine the long term effects of codisposing solid industrial waste with municipal refuse. The effect of the presence of a solid industrial waste (a steel flue gas dust) on the leachate produced by decomposition of municipal refuse was studied under simulated landfill conditions using large scale leach columns. A total of sixteen experimental test cells were used to investigate the influence of controlled and atmospheric moisture input, industrial waste loading and time on the leachate composition produced. A total of thirty-three parameters were measured. The research has shown that the addition of the industrial waste in the codisposal tests, did not degrade the quality of the leachate and in fact has improved the leachate quality over the two years that the columns have been operating.

C6 TECHNICAL AND ECONOMIC ASSESSMENT OF REVERSE OSMOSIS FOR THE TREATMENT OF LANDFILL LEACHATES. Thomas A. Krug* and Sandra McDougall, ZENON Environmental Inc. Burlington, Ontario.

This engineering study assesses reverse osmosis (RO) technology for the treatment of landfill leachate waters. Such waters can contain a wide variety of hazardous organic and inorganic compounds which render conventional treatment processes difficult to operate and create treatment and disposal problems for landfill operators.

Reverse osmosis is a pressure driven cross-flow filtration process capable of removing dissolved contaminants from waste waters. It is an accepted technology in many applications where high purity water is required and is being applied in many waste water applications for complete removal of contaminants. The technology may be applied to leachate water after only minor pretreatment or may be used as a polishing step after more extensive treatment.

Experimental work is currently underway using samples of leachate water from a landfill site where toxic organic comtaminants have been found. Preliminary testing involves evaluating pretreatment processes which may be appropriate before RO. Subsequent testing will examine operation of a RO test system to determine its efficiency in removing contaminants, and performance characteristics such as flux rate and membrane life. The economics of RO as compared with other treatment technologies will be assessed in the final stages of this work.

C7 ENHANCED SANITARY LANDFILL: A DEMONSTRATION TRIAL.

Glenn Vicevic*, Brian Forrestal, Al Stevenson, Ontario Research Foundation, Mississauga, Ontario, and Allan Martin, R. V. Anderson Associates Ltd., Toronto, Ontario, R. Rothfuss, Region of Peel, Brampton, Ontario, Matthew McKim, CMS Rotordisk, Mississauga, Ontario.

This paper will describe the concept of enhanced landfill operation to achieve more rapid stabilization of the site and increased volume and quality of recovered methane. The basic approach to achieving rapid stabilization is to run the landfill in a flooded condition to leach, as rapidly as possible, degradable organics from the refuse. The leachate is collected and treated anaerobically to produce a high quality methane gas stream. The treated leachate is returned to the landfill to leach out more organics. This theoretical concept was developed under a research contract from the Ministry of the Environment.

A follow-up study was commenced on April 1, 1987, in which the Ministry of the Environment is supporting a practical demonstration trial of the concept at the Britannia Road landfill site operated by the Region of Peel. The first Phase of this is a demonstration of anaerobic digestion of leachate. The paper will describe the experimental set-up and preliminary results obtained by November of 1987.

C8 SEWAGE SLUDGE COMPOST AS TURF FERTILIZER.

Jack Eggens*, Horticultural Science, University of Guelph, Guelph, Ontario, N1G 2W1.

This study, supported by the Ministry of the Environment and the Ontario Ministry of Agriculture and Food is designed to evaluate the effectiveness of a sewage sludge compost as a fertilizer for fine and medium turf swards.

The sewage sludge compost and commercially available organic and inorganic turf fertilizers were applied at equal rates of nitrogen on irrigated and non-irrigated homelawn type turf and on creeping bentgrass turf maintained as a putting green.

Ease of application of the sewage sludge compost with a drop type fertilizer spreader was similar to other organic fertilizers on turf mowed at 4 cm but tended to remain on the leaf blades of 5 mm mowed turf for an unacceptable period of time. There was no observable difference in winter injury, soil penetrometre readings, broadleaf weed invasion or proneness to disease between the sewage sludge compost and other commercially available organic or inorganic nitrogen fertilizers.

The paper will examine the effect of sewage sludge compost on the botanical composition of the creeping bentgrass-annual bluegrass sward, thatching tendency of the irrigated Kentucky bluegrass sward and the drought avoidance characteristics of the non-irrigated Kentucky bluegrass turf.

C9 DISPERSION OF THE STOUFFVILLE CONTAMINANT PLUME. I. Proulx*, R. N. Farvolden, E. O. Frind, Institute for Groundwater Research, University of Waterloo, Waterloo, Ontario.

A plume of contaminated groundwater has developed in the Oak Ridges Aquifer under the southwest corner of the Stouffville landfill site. Hydrogeological framework at the site was constructed from past studies and was presented at last year's Technology Transfer Conference. In the 1987 field season, three multilevel piezometers have been installed and monitored to obtain contaminant distribution in the main aquifer at critical locations.

Flow and transport models have been used in combination with geochemical and isotopic studies in the assessment of the plume behaviour. Cross-sectional flow simulations of the 60 m-thick aquifer demonstrated the large influence of stratigraphy on the flow field. The apparent sinking of the plume can be explained by preferential migration in gravel lenses of the silty sand aquifer.

A 2D analytical transport model was used to simulate contaminant transport in a cross-section from a temporary source at the water table under former disposal lagoons. An average migration velocity of 25 m/y and a longitudinal dispersivity of 20 m were obtained from calibration of the model with historical chloride breakthrough curves.

Historical quarterly monitoring of chloride, conductivity, sulphate and phenols started in the early 70's. Since 1985, quarterly monitoring also includes calcium, magnesium, sodium, potassium, alkalinity and dissolved organic carbon. Historical and recent information is used to describe the Stouffville plume evolution. Attenuation characteristics of the aquifer were obtained by comparison of reactive ions and conservative chloride migration. Tritium concentration at different locations and depths were used to locate areas where recharge enters the aquifer, and to discriminate between zones of groundwater of different age.

C10 THE ECONOMIC BENEFITS OF PREVENTING GROUNDWATER CONTAMINATION.

John P. Hoehn and David Walker,* Depts. of Agricultural Economics and Resource Development, Michigan State University, East Lansing, MI 48824, USA.

Groundwater is an important source of high quality, low cost water for drinking and residential purposes. The paper develops procedures for estimating the benefits of protecting drinking water supplies from contamination. If contamination were to occur, the costs of providing potable water increase. These increased costs impose economic damages on both consumers and suppliers of groundwater. Thus, an important fraction of the benefits of high quality groundwater are the lower costs of potable water.

The benefits of groundwater protection are estimated using a model of residential water demand and supply. Given initial conditions such as water price, system size, and climatic conditions, the model computes water prices, water quantities demanded, and economic damages subsequent to a contamination event.

The model is applied in estimating the benefits of protecting groundwater from nitrate contamination. The nitrate case shows that benefits vary with the initial conditions. In a small, rural water system that serves 500 households, the annual benefits of avoiding 10 milligrams per liter of nitrate range from $130 to $166 (U.S.) per household. Prevention of 40 milligrams of nitrate per liter increases benefits by fourteen percent.

C11 ASSESSMENT OF OVERLAND FLOW, BIOLOGICAL TREATMENT TECHNOLOGY FOR REMOVAL OF ORGANIC COMPOUNDS FROM GROUNDWATER. R. Woeller, * Water & Earth Science Associates Limited, Carp, Ontario and D. Cook, Ontario Ministry of the Environment, Kingston, Ontario.

This study, funded in part by the Ministry of the Environment, provides an assessment of the performance of an overland flow, biological treatment process to effectively reduce levels of organic compounds in contaminated groundwater to acceptable concentrations for discharge to receiving water bodies. A gasoline spill in Delta, Ontario has contaminated the local bedrock and overburden aquifers. Remedial work entailed the installation of a purge well and operation at a flow rate of 360 L/S. Low but carcinogenic levels of benzene and PAH compounds in the purge well effluent required treatment prior to surface water discharge. Low cost overland flow, biological treatment technology rather than conventional treatment technology was implemented to reduce contaminant levels prior to surface water discharge. The paper provides details of the construction of the overland flow, biological treatment system and a preliminary assessment of the performance of the system during the first six months of operation. Benzene at concentrations of 100-150 ug/L, toluene at 10-30 ug/L, ethylbenzene at 90-150 ug/L, xylene at 80-230 ug/L and naphthalene at 30 ug/L are characteristic contaminant concentrations in the purge well effluent. At the outlet of the treatment system, contaminant concentrations are generally at or below laboratory detection levels (1 ug/L).

C12

OPTIMAL RECOVERY OF LEACHATE UNDER SANITARY LANDFILLS. J.W. Molson*, E.O. Frind, R.N. Farvolden, Institute for Groundwater Research, University of Waterloo, Waterloo, Ontario.

Numerical simulations have been performed to evaluate the efficiency of tile drain leachate collection systems beneath sanitary landfills. A two-dimensional finite element model for steady state, saturated flow was used to compute potentials and streamfunctions within the tile drain domain. The system response was studied under several realizations of drain system geometry, subsurface heterogeneities and imposed regional flow regimes.

Simulations were concentrated on a simplified half-cell representation of the drains and on a larger, regional flow scale which encompasses the landfill drain network. A specialized triangular element discretization scheme has allowed drain response to be more accurately simulated at the regional scale. Regional flow conditions near the drains were established by adjusting their position within a Hubbert-type flow field. The study also included simulations with landfill caps and liners and permeability contrasts at the local and regional scales.

Results indicate that the regional flow system must be considered to obtain an accurate prediction of tile drain performance. Drain collection efficiency varies significantly between recharge and discharge conditions and under certain circumstances, tile drainage itself can have a strong influence on regional groundwater flow.

C13 EFFECTS OF INCREASING AMOUNTS OF NON-POLAR ORGANIC LIQUIDS IN DOMESTIC WASTE LEACHATE ON THE HYDRAULIC CONDUCTIVITY OF CLAY LINERS IN SOUTHWESTERN ONTARIO. Robert M. Quigley* and Federico Fernandez, Geotechnical Research Centre, Faculty of Engineering Science, The University of Western Ontario, London, Ontario.

Laboratory studies have shown that the hydraulic conductivity, k, of a clay liner can be greatly increased by some concentrated organic solvents. Water-soluble organic liquids such as acetone, alcohols and dioxane are capable of displacing the water in the pores, collapsing the double layers around the clay particles and rendering a clayey barrier as pervious as sand.

Hydraulic conductivity tests on water-compacted clays permeated with domestic waste leachate spiked with increasing amounts of ethanol (ε = 35) and dioxane (ε = 2), respectively. The results show that hydrocarbon contents greater than 70% are required to produce significant increases in k even at zero confining pressures. Within this range of organic contents, increased permeant viscosity results in significant (up to 70%) decreases in k. For concentrated organic liquids the application of vertical confining pressures suppresses a large portion of the increases in k as a result of vertical consolidation and K_o effects that reduce side wall leakage.

Hydraulic conductivity tests are also presented for dry clays mixed and permeated with aqueous solutions of hydrocarbons. This fundamental study illustrates the combined effects of permeant viscosity, double layer collapse and fabric on k. Pore size distributions obtained by mercury intrusion porosimetry are presented as an aid in interpreting variations in soil fabric.

Extensive studies are continuing to establish the magnitude of the in situ stresses required to minimize liquid hydrocarbon related damage.

C14 EVALUATION OF CONTAMINANT VELOCITY AND LOW-PERMEABLILITY FRACTURED SHALE. Gareth Thomson, Ray Blackport, John Cherry*, and Ed Sudicky, Institute for Groundwater Research (IGR), University of Waterloo, Waterloo, Ontario, N2L 3G1

Low permeability fractured shale underlies many waste disposal and industrial sites in the Toronto-Mississauga-Hamilton-Niagara area, commonly at shallow depths. Previous IGR research suggests that these fractures may be significant conduits for contaminant mass transport from these sites. Consequently, IGR is currently engaged in research to evaluate and compare several methods for groundwater velocity determinations in fractured shale, and to assess the potential for attenuation of contaminants by dispersion and matrix diffusion.

In 1986 five boreholes spaced 15 m apart were drilled in a "five-point" or cross formation at Clarkson, Ont. Field work in 1987 focussed on a fracture zone (FZ1) which is located between 10.4 and 10.7 m depth in all boreholes: falling head tests conducted in all five holes gave transmissivity values between $10^{-5}$and 10^{-6} m^2/sec for FZ1. A five hour pump (interference) test produced data from three of these wells which show typical Theis behavior with no boundary effects, transmissivity values which are in excellent agreement with the falling head tests (5 x $10^{-6}m^2$/sec) and a low storativity of 3-5 x 10^{-7}. Results from the remaining borehole indicate that FZ1 may pinch out towards the west.

Parameters derived from hydraulic testing are usually all that is available in conventional site studies for prediction of groundwater velocity. In our study, however, a planned natural gradient tracer test in the fracture zone FZ1 would give the "actual" tracer velocity which can then be compared with predicted values.

C15

ORIGIN AND STATE OF NEAR SURFACE FRACTURES IN THE CLAY TILLS OF SOUTHWESTERN ONTARIO. Maurice B. Dusseault, Dept. of Earth Sciences, University of Waterloo.

There is conflicting evidence as to the condition of the fractures in the shallow clayey till of Southwestern Ontario. At one site, information from conventional piezometers suggest that fractures below 3.5 m are closed, shallower ones being at least partially open. Various sources using various methods suggest that the lateral stresses at shallow depths are greater than the vertical stresses, a finding incompatible with the previous statement. Clay mineral analyses from some sources imply the presence of swelling clays, a viable mechanism to close desiccation fractures, but not all evidence supports this interpretation. The large horizontal transmissivity of the upper metre or so is evident from rapid underground runoff from flat terrain, implying open fractures. A large diameter borehole, hand cleaned, gave some data which could be interpreted as evidence of open fractures.

The issue is not resolved. The paper will discuss the mechanisms and procedures used to give these anomalous results, and will show why each technique of itself cannot yield the single correct answer. Among the issues discussed are non-linearity of permeability in constant head tests; site-specific differences in fracture fabric and state; the origin of the fractures; borehole smear affecting permeability; and the difficulty of obtaining any reliable fracture permeability measurement in the laboratory or in the field in soft clays. It is recommended that for the time being, sites in these clays should be designed as if the fractures in the upper 4 - 5 m are indeed open and provide a horizontal permeability of from several times to 1.5 orders of magnitude greater than that of the intact unfractured clays. This conservative approach is warrented at this time in view of the conflicting data.

C16

WASTE MANAGEMENT PLANNING FOR PHARMACEUTICAL INDUSTRY -- PHASE II. "DATA ANALYSIS AND ASSESSMENT".

Robert A. Stairs,* R.C. Makhija, Department of Chemistry, Trent University, Peterborough, Ontario.

Data on waste generated by 35 establishments, including six hospitals, have been obtained, which are being analyzed and assessed. Similarly, we have received waste data reported by 17 establishments including 3 hospitals to the Ministry of the Environment under Regulation 309. The comparison of the data is underway and results of our findings, with recommendations, will be presented.

Written requests were made to pharmaceutical manufacturers to provide us with a list of their products in order to correlate pharmaceutical names with chemical names and identify any chemicals used that come under Regulation 309, schedule 2(A). Only 10 manufacturers have replied to our request. Plant visits are planned during this summer to obtain data on waste streams and costs for disposal. Data will be obtained on currently available facilities and systems for pharmaceutical waste disposal.

The paper will discuss our findings on waste streams from plants, comparitive results of our data with MOE (waste reported in 1986) and classification under Regulation 309.

C17 MUNICIPAL SOLID WASTE - FEASIBILITY OF GASIFICATION WITH PLASMA ARC. G.W. Carter, A. Tsangaris,* Resorption Canada Limited, 2465 Stevenage Drive, Ottawa, Ontario, K1G 3W2.

Resorption Canada Limited (RCL), in conjunction with Ontario Hydro Research Division and OBOE Engineering Limited, is conducting a feasibility study of the plasma gasification of Municipal Solid Waste under a cost sharing agreement with the Ontario Ministry of Energy. The objectives of the study are to demonstrate the operational and environmental characteristics of the plasma gasification of MSW in order to increase the visibility and potential acceptability of the use of plasma technology in such an application. This experimentation is expected to largely substantiate the postulated process characteristics of plasma gasification of MSW, the most salient of which include: a 4-5 fold increase in usable output energy compared to input electrical energy, a product gas with a potential heating value of 300-350 BTU/scf, and a potential minimal requirement for environmental controls for either the subsequent combustion of the product gas or for the disposal of the virtually inert byproduct slag. All experimentation is being conducted in the RCL Plasma Research Facility in Ottawa, Ontario.

Stage 1 of the project, which will determine the Higher Heating Value of the product gas and the total process heat balance, commenced 1 April 1986. Stage 2, which will determine the environmental acceptability of the process and the subsequent combustion of the product gas, is scheduled for commencement late in 1987 dependent on the final results obtained through Stage 1. Project costs are also being shared by Plasma Energy Corporation of Raleigh, North Carolina, and the Ontario Ministry of the Environment.

C18

DEVELOPMENT OF GUIDELINES TO CONTROL THE DISPOSAL OF WASTES AS BACKFILL MATERIAL IN ONTARIO.

Maria Kelleher*, George Zukovs and Saleem Dedhar,
CANVIRO Consultants, Mississauga, Ontario.

The project was carried out in two phases. Phase I involved development of guidelines for the classification of industrial waste materials for backfill and construction applications, based on bulk and leachate quality analyses. The classification options developed included:

- lakefill and shoreline disposal
- restricted land use
- construction use
- immobilization

Phase II of the study involved establishing the effectiveness and reliability of the proposed guidelines through detailed bulk quality characterization and leachate testing of backfill from selected sites, and included hydrogeologic investigations of the chosen sites

A detailed site selection process was developed to determine the four sites for detailed study. The backfill materials of particular interest were:

- blast furnace slag
- fly ash and/or bottom ash
- foundry sand
- cement kiln dust
- sewage sludge incinerator ash

Backfill material at each site is characterized for leachate and bulk characteristics. Groundwater is sampled for a number of parameters.

The proposed guidelines will be modified as required, based on the results of these field investigations.

CP1 SAMPLING GROUNDWATERS FOR VOLATILE ORGANIC CONTAMINANTS. James F. Barker*, Todd A. McAlary, and Gary M. Travis, Institute for Groundwater Research, University of Waterloo, Waterloo, Ontario, N2L 3G1.

The determination of volatile organic concentrations in groundwaters might be biased due to loss of these organics during sample collection. This study examined the extent of such bias in a series of laboratory simulations of typical protocols for groundwater sampling. The major sources of bias were found to be sorption onto sampling equipment and volatilization into headspace.

A reservoir of groundwater was sampled via a gas-drive pump and a suction lift pump and both systems were found to introduce negative bias in the subsequent data. The bias ranged from 0.8 to 22% for a range of volatile chlorinated hydrocarbons. The suction lift pump seemed to induce more loss generally.

Where monitoring wells are recharged very slowly due to the low permeability of the media, we suggest that even more loss of volatile organics can occur via volatilization into the headspace created in the well sand pack and well casing. Again, a controlled laboratory experiment was conducted to assess the loss of volatile organics via sorption onto the sand pack and well screen and via volatilization during well recharge through a dewatered sand pack. Losses of up to 70% of the volatile organics were observed when well recharge required one hour. We conclude that the conventional sampling of monitoring wells in low permeability materials may produce unacceptable negative bias in the resulting volatile organic concentrations.

CP2

SLOW RATE INFILTRATION LAND TREATMENT AND RECIRCULATION OF LANDFILL LEACHATE IN ONTARIO. R.A. McBride,* A.M. Gordon and P.H. Groenevelt. Departments of Land Resource Science and Environmental Biology, University of Guelph, Guelph, Ontario.

This three-year study represents an extension of M.O.E.-funded research initiated in 1986 to investigate the engineering, economic and environmental feasibility of land treatment of MSW leachates in Ontario ("Treatment of Landfill Leachate by Spray Irrigation - Muskoka Lakes". Environment Ontario Research Report, April 1987). Plot-scale perturbation installations involving three irrigation methods (spray, trickle and sub-irrigation) at three application rates (3.5, 7.0 and 14.0 $mm \cdot d^{-1}$) are being established at four landfill locations for detailed experimentation in 1988. Such a system is operational at the Muskoka Lakes site in 1987. In-ground lysimeters have been installed with various vegetative covers to study the recirculation of MSW leachates through landfills with clay surface liners.

Work is continuing on vegetative stress and soil property characterization at two locations where spray irrigation of leachates is ongoing (Muskoka Lakes and Niagara-on-the-Lake). A portable photosynthesis system is being used to monitor leachate irrigation effects on leaf stomatal resistance to CO_2 and water flux. An investigation of photosynthetically-active and infra-red radiation balances on understory leaves stained by spray irrigation is also being carried out with a portable spectroradiometer. Soil microbial biomass and respiration are being periodically monitored through the irrigation season.

Electron spin resonance (ESR) is being used to better characterize the organometallic complexes present in leachates and allow their fate in a soil environment and their role in the formation of indurated layers in certain soil types to be assessed. Leachate strength is being indexed with LC_{50} toxicity tests using Daphnia pulex.

D1

APPLICATION OF POLYMERIC LIQUID CRYSTAL CAPILLARY COLUMNS FOR SEPARATION OF 2,3,7,8-TCDD AND TCDF BY GC-MS TECHNIQUES

K. P. NAIKWADI AND F. W. KARASEK, Department of chemistry ,university of Waterloo, Waterloo, Ontario, Canada, N2L 3G1.

Since the initial disclosure of the use of polymeric liquid crystal (PLC) stationary phases in capillary column gas chromatography for the separation of polycyclic aromatic hydrocarbons (PAH), extensive work has been carried out on development of such columns for isomer specific separation and quantitation of the recognized carcinogen benzo[a]pyrene in environmental samples. However, PLC capillary columns have not been used for the analysis of PCDD and PCDF.

The linear and planer solute molecules have longer retention as compared to non-linear and bulkier molecules on PLC column. The positive identification and quantitation ofpolychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in sample matrices that contain high levels of other naturally occurring compounds and other chlorinated industrial pollutants has presented several difficulties. The conventional capillary columns are inadequate for isomer specific (2,3,7,8-TCDD) separation in a congener group and separation of interfering compounds (PCB) from PCDD and PCDF.

This paper will describe the potential of PLC capillary columns for the separation and the identification of PCDD and PCDF. The results of isomer specific separation of 2,3,7,8-TCDD from rest of the tetrachlorodibenzo-p-dioxin isomers and from PCB will be presented.

D2

EVALUATION OF MONITORING TECHNIQUES FOR DIOXINS IN AMBIENT AIR

C.Tashiro[1], R. Clement[1], A. Szakolcai[2], W. Chan[2]

[1] Laboratory Services Branch, Ontario Ministry of the Environment, P.O. Box 213, Rexdale, Ontario

[2] Air Resources Branch, Ontario Ministry of the Environment, 880 Bay Street, Toronto, Ontario.

Chlorinated dibenzo-p-dioxins (CDD's) and dibenzofurans (CDF's) in ambient air have not been widely investigated. A few measurements of 2,3,7,8-4CDD in ambient air using high volume air sampling with glass fibre filters and polyurethene foam (PUF) cartridges have been reported. However, no validated methodologies for sampling ambient air for the full range of CDD's/CDF's have been presented. Proper validation requires spiking studies of multiple CDD/CDF congeners to determine breakthrough of both the glass fibre filter and the PUF cartridges, and recovery studies to determine extraction efficiencies.

The Ontario Ministry of the Environment ambient air sampler for CDD's/CDF's consists of a glass fibre filter followed by a single or dual PUF cartridges. Low and high-level CDD/CDF surrogate spiking studies have been performed to determine the sampling efficiency of this device. ^{13}C labelled standards were spiked separately onto the glass fibre filter and the PUF cartridges to determine breakthrough.

Initial results from a 24 hour sampling with a glass fibre filter and a single PUF indicated good spike recoveries for both the PUF and filter and some breakthrough of the lower congener spikes from the filter to the PUF.

D3

ANALYSIS OF DIOXINS, FURANS AND OTHER POLYCHLORINATED POLLUTANTS IN FISH, T.S. Thompson*, K.P. Naikwadi, and F.W. Karasek, Department of Chemistry, University of Waterloo, Waterloo, Ontario.

Many of the open column chromatographic methods used for the cleanup of fish tissue extracts employ alumina packing for the separation of PCDDs and PCDFs from PCBs and other chlorinated pollutants. Based on this fact, an HPLC column containing alumina packing material was prepared. A new cleanup procedure was devised in which the HPLC fractionation on the alumina column replaces the multi-step open column chromatographic method employed in the Dow cleanup. The new method allows for the simultaneous determination of PCDDs, PCDFs, and other polychlorinated pollutants of interest.

D4

"SEMI-AUTOMATED WATER SAMPLER FOR DIOXIN DETECTION AT PPQ LEVELS"

Dr. B. Hollebone[1], Lorna Brownlee[1], Cathy Shewchuk[1], and Brian Jobb[2], Ron Hunsinger[2], Matt Uza[2], Helle Tosine[3], Sharon Suter[3]

[1] Carleton University, Chemistry Department, Ottawa, Ontario, K1S 5B6,

[2] MOE, Water Resources Branch.

[3] MOE, Laboratory Services Branch

The Ministry of the Environment is responsible for a monitoring program for organic contaminants in drinking water. It is necessary to be able to detect and quantify accurately the levels of highly toxic classes of chlorinated dibenzo-p-dioxins (CDD's) and chlorinated dibenzofurans (CDF's) in the environment. However, these compounds are present in trace amounts so it is necessary to analyse large volumes of water. A sampling unit was designed to be capable of preconcentrating 100 L of treated or raw water for analysis of CDD's/CDF's at the parts per quadrillion (ppq) level. This unit contains a filtering system to collect particulate matter followed by columns with XAD resins to adsorb dissolved organics, both of which can be removed for analysis. To ensure optimum reproducibility and recoveries during analysis the system is operated under microprocessor control and a facility has been built into the field sampler for dynamic additions of internal standards. Examples of system performance will be given.

D5

HPLC FRACTIONATION PROCEDURES FOR THE ISOMER SPECIFIC ANALYSIS OF PCDD AND PCDF IN ENVIRONMENTAL SAMPLES, T.S. Thompson and F.W. Karasek, Department of Chemistry, University of Waterloo, Waterloo, Ontario.

The compound classes known as polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) consist of a large number of different congeners. There are 75 possible PCDD isomers while there are 135 different PCDF molecules. Most environmental samples found to contain PCDDs and PCDFs have a large number of different isomers present. The large variations in the toxicity of the individual compounds makes it desirable to know the levels of the most toxic species rather than a total amount of PCDDs and PCDFs. However, the large number of isomers usually present and their similar chromatographic behaviour make isomer specific analyses very difficult. Since there is no single GC column capable of resolving all PCDD and PCDF isomers nor even the species of most interest, a multi-step chromatographic separation must be employed. In this study, the use of HPLC for sample fractionation prior to GC/MS analysis was investigated. The application of normal and reverse phase HPLC columns were compared with respect to their separation capabilities. Flyash is believed to contain virtually all of the various PCDDs and PCDFs and therefore this environmental matrix was chosen for the evaluation of the HPLC separations.

D6

DEVELOPMENT OF A ROBOTIC SYSTEM TO AUTOMATE THE ROUTINE ANALYSIS OF FISH TISSUE BY ACID DIGESTION/SOLVENT EXTRACTION. Gerald Ladwig, Cecilia Chan, John Martin - Mann Testing Laboratories Ltd.; George Crawford - Ministry of the Environment.

This project, sponsored by the Ministry of the Environment, was undertaken to automate an extraction procedure currently used at MOE Laboratories for the analysis of trace levels of PCB's and pesticides in fish.

Objectives of this system are to (i) improve precision and accuracy; (ii) improve sample throughput; (iii) provide automated data reduction, reporting and archiving capabilities.

To meet these objectives, substantial method development was performed in order to convert manual procedures to robotic procedures by working within hardware limitations such as the robot's working envelope, memory/dictionary capacity and available "senses".

The software written for this system utilized structured programming techniques and top-down design, which contributed greatly to ease of maintenance and testing and will provide the necessary flexibility for future method modifications and enhancements.

Through the interfacing of a remote computer, the capabilities of the Zymark Controller were expanded so an operator can enter sample attributes. The data returned from the robot is stored in the PC and used to generate a report for each run. File structures are provided for future extentions such as uploading of data files to a mainframe computer.

System performance was throughly evaluated by running a large number of blanks, spikes and fish samples and also by direct observation of the system for a 3 day run.

D7 CHARACTERIZATION OF THE FECAL INDICATOR BACTERIAL FLORA OF SANITARY SEWAGE WITH APPLICATION TO IDENTIFYING THE PRESENCE OF SANITARY WASTE IN STORM SEWERS. P.L. Seyfried, E.M. Harris, I. Huh, R. Harmandayan, and E. Hani, Department of Microbiology, Fitzgerald Building, University of Toronto, Toronto, Ontario.

Samples were collected from surface runoff as well as from specific sites in sanitary sewer lines and in priority and nonpriority storm sewers during periods of wet and dry weather. Densities of fecal coliforms, Escherichia coli, fecal streptococci, enterococci, Pseddomonas aeruginosa, Clostridium perfringens, and Bifidobacterium were determined in each of the samples. Over 2,000 fecal streptococcal and 1,400 P. aeruginosa isolates were characterized further by biochemical testing, serotyping or genotyping. Streptococcus faecalis var.liquefaciens and S. faecium were shown to be uniformly distributed among the high priority sewage. It is noteworthy that a high proportion of these S. faecalis isolates produced an acid curd in litmus milk. It would appear from the data collected that although P. aeruginosa densities were markedly higher in sanitary and high priority storm sewage, serotyping of the isolates does not help to identify sources of pollution. For example, 06 was the predominant P. aeruginosa serotype isolated from all samples. Genotyping results may yield more information. As might be expected, changes in bacterial indicator populations were best observed during periods of dry weather. Under dry conditions all indicator organisms, including Bifidobacterium sp., were present in higher levels in samples taken from the high priority storm sewage in comparison with the nonpriority samples. These preliminary results suggest that the characterization of specific indicator bacteria can be used to facilitate the tracing bacteria the tracing of illegal sanitary connections to priority storm sewers in the Metropolitan Toronto area.

D8

PATHOGENESIS OF NEOPLASTIC DISEASES AFFLICTING FERAL FISH. M.A. Hayes, I.R. Smith*, H.W. Ferguson, Fish Pathology Laboratory, Ontario Veterinary College, University of Guelph, Guelph, Ontario, N1G 2W1

Skin and liver neoplasms (tumors) affect bottom-dwelling fish in Lake Ontario and other polluted sites in the Great Lakes. Skin papillomas affecting white suckers (Catostomus commersoni) from Lake Ontario were examined sequentially to determine if these tumors were persistent or transient. Affected white suckers were removed from their polluted habitat and kept in "clean" laboratory tanks over a 12 week period. Sixty percent of the skin papillomas disappeared during this time, but 41% of the surviving fish developed new tumors. The disappearance of many tumors suggests that these papillomas are transient proliferative lesions, possibly initiated in the polluted environment, while the appearance of new tumors suggest that chemicals are not the only agent capable of promoting papilloma development in these fish. The liver tumors found in many of these same fish are associated with chronic inflammatory disease of bile ducts. In order to evaluate the reversibility of hepatic disease and neoplasms, it was necessary to identify affected live fish at the time of capture. The chemical alpha-naphthylisothiocyanate was used to induce bile duct necrosis in rainbow trout. Serum enzyme analysis suggested that elevations in the enzyme alkaline phosphatase is most useful for detecting biliary disease in live fish. Serum enzyme levels of wild caught white suckers with and without liver disease or tumors are being compared with histopathological findings to determine if serum biochemical analysis is a useful in vivo test for liver disease in white suckers.

D9

RECOMBINANT DNA TECHNOLOGY FOR DETERMINING SOURCE INPUTS OF BACTERIAL POLLUTION IN AQUATIC HABITATS. Wayne C. Bradbury, S. Patel, S. Poland, M.A. Marko, Departments of Microbiology, Toronto General Hospital, University of Toronto, Toronto, Ontario.

In constrast to biochemical studies, DNA sequence studies using Restriction Endonuclease Analysis (REA) and DNA:DNA hybridization analysis give more reliable definitions of bacterial taxonomy and may be the key to classifying host-specific fecal stretococci.

We have developed techniques to identify the different host-specific sources (e.g.human, animal, bird) of pollution present in the aquatic ecosystem of the Toronto harbourfront.

Using a Bam HI REA library of biochemically- and source-defined fecal streptococci, human, goose and gull DNA probes were prepared for hybridization studies. These host-derived DNA probes enable us to discriminate the different hosts as sources of pollution and to enumerate the contribution of each input source to the over-all bacterial pollution profile.

This technique offers a much improved identification system for specific classification of fecal streptococci as pollution indicators.

D10 LIQUID AND SOLID SAMPLE INTRODUCTION FOR INDUCTIVELY COUPLED PLASMA ATOMIC EMISSION AND MASS SPECTROMETRY. Eric Salin*, Laurent Blain, Lyne Gervais and Robert Sing. Department of Chemistry, McGill University, 801 Sherbrooke St. W. Montreal, P.Q., H3A 2K6.

Sample introduction methods continue to be a major area for research in inductively coupled plasma (ICP) atomic emission spectroscopy (AES). The recent development of ICP mass spectrometry (MS) has led to the evaluation of some unique icp-aes sample introduction systems for ICP-MS. The wire loop direct sample introduction system for plasma based spectrometry will be described. The technique involves placing a liquid sample on a wire loop. The loop is moved underneath the plasma where it is dried in approximately 30 s. The wire loop with sample is then inserted rapidly into the plasma. The sample is vaporized rapidly and produces momentarily a large concentration of the analyte in the plasma. Because the sample is dry the resulting mass spectrum has drastically reduced oxygen interferences. The precision is excellent with automated sample application and can be better than 1% relative standard deviation. The effect of some potential interferences will be discussed as well as detection limits and precision. An enormous number of samples are found naturally in the solid or semisolid state. Conversion of these samples to a liquid format for elemental analysis by flame, electrothermal or plasma spectrometric methods involves additional time as well as the possibility of sample contamination and loss of certain volatile elements. Clearly, a method which will allow the direct analysis of solids at the trace level would be of great advantage to the Ministry of the Environment. The direct sample insertion device (DSID) when used with the inductively coupled plasma ICP for atomic emission spectrometry provides this capability. The technique produces a transient signal which may require modification to conventional detection instrumentation. The application of the DSID with the new Thermo Jarrell Ash ICAP 61 ICP system will be discussed. Future strategies and expectations will be presented.

D11

SCREENING METHODS FOR AIR AND WATER SAMPLES USING INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY. Jon C. Van Loon, Department of Geology, University of Toronto, Toronto M5S 1A1 Ontario.

Part I: A resistively heated filament is used to volatilize samples into the carrier gas stream of a plasma for analysis by plasma source mass spectrometry. Two types of filaments have been tested, graphite and rhenium. A 3-step continuously variable temperature, power supply was designed and built to power the filaments. With this unit drying, ashing and volatize thermal programs can be set up to operate independently. Instabilities in the gas flow system are still too large. A redesign was done so both the electrode post mounts and glass envelope were streamlined to help maintain the integrity of the tangentially swirling gas flow. At the time of writing this new design is being tested. Results are being obtained for a variety of water and solid, environmental, standard reference samples.

Part II: The inductively coupled plasma mass spectrometer was interfaced to be used as a detector for gas chromatography. This can be easily done using a heated transfer line. To prevent carbon build up in the torch, oxygen gas (about 10% of the total carrier gas flow) must be injected into the transfer line. Results have been obtained for both methtin and methyl selenium compounds. Detection limits to this date for Se are about 1 order of magnetude poorer than those reported by the most sensitive approach. Determinations must be done using $^{78}Se^{+}$ instead of the more sensitive $^{80}Se^{+}$ ($^{80}Ar_2^{+}$ interference).

D12

ADVANCED MASS SPECTROMETRIC TECHNIQUES FOR THE IDENTIFICATION OF UNKNOWN ORGANIC COMPOUNDS. V.Y. Taguchi, E.J. Reiner, D.T. Wang and O. Meresz, Ministry of the Environment, Rexdale, Ontario.

Identification of unknown organic compounds by gas chromatography/mass spectrometry (GC/MS) usually involves comparison of the mass spectrum of the unknown to a reference library of mass spectra of known compounds. This technique of library searching is limited by the number of entries in the library and the capacity of the computer to assimilate and search larger libraries. Mass spectra that cannot be identified through this technique must be interpreted from first principles. Advanced mass spectrometric techniques that can aid in the interpretation include linked scanning, mass analyzed ion kinetic energy spectroscopy (MIKES) and accurate mass (empirical formula) determinations. These techniques will be explained and demonstrated on model compounds. Applications to environmental samples will be presented.

D13 DEVELOPMENT OF THE GC/MED SYSTEM FOR HAZARDOUS WASTES; M.C. Nimjee, M. Dancziger and L.L. Danylewych-May,* Barringer Magenta Limited, 304 Carlingview Drive, Rexdale, Ontario M9W 5G2.

The objective of this study was to develop a fast screening method of chemical waste based upon the helium microwave plasma emission detector (MED) interfaced with a gas chromatograph. Six spectrometer channels were selected to continuously monitor atomic emission for C1,R,BR,P,S and C.

Detection limits between 1-20 pg/s and selectivity of two to three orders of magnitude have been observed for simple halogenated hydrocarbons using a Beenakker cavity with a capillary torch (0.8 mm ID, 6 MM OD plasma sustaining quartz tube) operated at 80 watts. However, poor sensitivity (high nanogram range) was observed for PCB's. Increasing the microwave poser dramatically increased the sensitivity of PCB's, however, continuous operation above 85 W reduced the lifetime of the torch. Operating powers in excess of 120 watts for the capillary torch were required for efficient PCB decomposition within the plasma, therefore, an alternative torch design was investigated to allow plasma operation at higher powers.

A 4 mm ID plasma torch with tangential cooling and plasma focusing was found to be suitable for both high solvent or matrix loading and high power operation. Increasing the operating power to 180 watts increased the sensitivity to PCB, however, the sensitivity to other analytes decreased. This decrease appeared to be dilution from the increased gas flow. Limitations were also observed with respect to the spatial distribution of the plasma which has resulted in difficulties in reproducibly focusing the plasma source onto the entrance slit of the spectrometer. The limitations of the current torch design will be reviewed with respect to the implications of the MED as a rapid screening technique for chemical wastes.

D14

TOWARDS A CHEMICALLY SELECTIVE LIPID MULTI-LAYER WAVEGUIDE: ARTIFICIAL CHEMORECEPTION IN THE OPTICAL REALM.

Ulrich J. Krull*, Ken W. Stewart and R. Stephen Brown, Chemical Sensors Group, Department of Chemistry, Erindale College, University of Toronto, Mississauga Road North, Mississauga, Ontario. L5L 1C6.

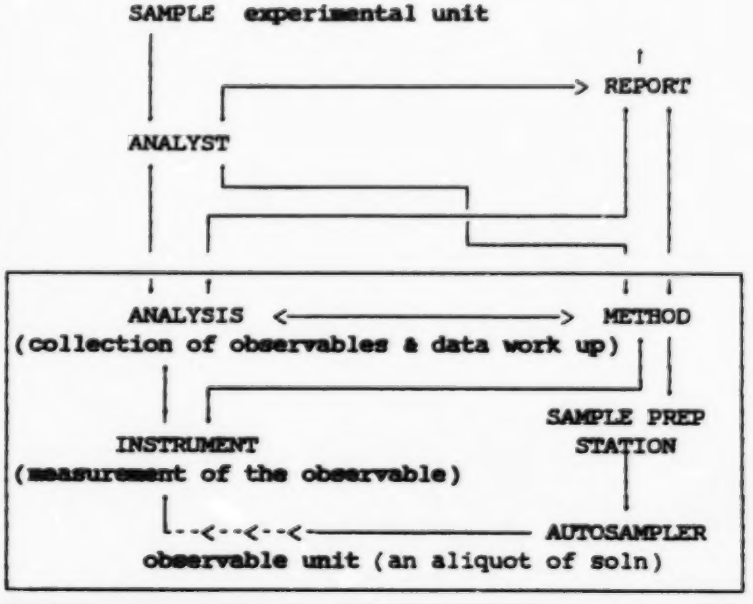
This work is directed towards the development of a selective chemical sensor for the detection of pollutants and toxins at trace levels in atmospheric and aqueous samples. The transduction process makes use of an optical analogue of chemoreception, where chemical selectivity is derived from receptor molecules which are located in organized lipid membranes. Optical chemical sensors, and in particular fibre-optic systems (optrodes), offer significant advantages with respect to remote sensing, internal calibration, distributed sensing and multidimensional analytical information in the form of wavelength, intensity, polarization and lifetime parameters.

Previous work with optrodes has produced both intrinsic and extrinsic sensor systems, but these cannot be readily interfaced with the ultrathin lipid membranes used in artificial chemoreception. A new concept to maximize membrane stability and analytical sensitivity involves the preparation of chemically-selective multi-layered lipid films which can provide optical transmission by total internal reflection. Such chemically-selective monomode optical light-guides provide analytical information in the form of fluorescence or refractive index alterations, induced by physical perturbations of the lipid membrane structure by receptor binding to target analytes.

Present work has investigated lipid deposition by Langmuir-Blodgett techniques on opaque surfaces of silicon crystals, which provide structural waveguide support, and the opportunity for thickness and refractive index characterization by ellipsometry. Fluorescence and refractive index responses to membrane perturbations have been demonstrated.

D15 DEVELOPMENT OF ACexpert. 1. DESIGN OF AN EXPERT SYSTEM FOR AUTOMATED METAL ANALYSIS BY ATOMIC ABSORPTION SPECTROSCOPY. William R. Browett, Timothy A. Cox and Martin J. Stillman*, Department of Chemistry, University of Western Ontario, London, Ontario, N6A 5B7.

The objectives of this research study are to develop an expert system that can be used to control all aspects of metal ion analysis carried out by the technique of AAS. The system will provide (i) real-time control of solution preparation, sample dispensing and sequence control from an autosampler, (ii) control of the instrumental settings and data acquisition, and (iii) an estimation of the quality of the data obtained by the instrument. On the chart drawn below, arrows represent the flow of the sample through the laboratory, the flow of analytical information, or the flow of process control information. ACexpert is designed at present to provide complete control of all features contained within the box.



D16 SOLID PHASE DERIVATION OF ORGANIC ACIDS FROM AQUEOUS MATRIX: AN APPROACH TO AUTOMATION OF ANALYTICAL DERIVATIZATION REACTIONS. J.M. Rosenfeld and S. Sandler, Department of Pathology, McMaster University.

Derivatization of organic acids for Pentafluorobenzyl Bromide (PFBBr) is a standard procedure for determination of this class of analyte in environmental samples. In current methods (eg EPA 604) such derivatization is catalyzed by 18-crown-6 ether phase transfer carbonate from solid K_2CO_3 into acetone. This derivatization is carried out after extraction and concentration of the analytes. It is thus relatively difficult to automate. More important, the catalyst is highly toxic and a serious safety risk.

In order to circumvent these problems we investigated a complete solid phase sample preparation technique. Such methodology can simplify manual methods and can also be the basis of automated techniques. Central to this process is the solid phase derivatization of organic acids on XAD-2. This reaction takes place directly from water with the non toxic resin as the catalyst and adsorbent. The pentafluorobenzyl (PFB) derivatives are retained on the resin which is simply isolated by filtration or aspiration and the derivatized analytes recovered by elution.

The initial study focused on derivatization of 2,4 Dichlorophenoxy Acetic Acid (2,4DPA). Optimum reaction conditions for the derivatization were developed. It was also demonstrated that the PFB derivative of 2, 4DPA can be efficiently transferred without intermediate isolation or concentration from the resin to a column of silica gel with a hexane eluate and recovered from the normal phase column in 5% acetone hexane. Superior chromatographic separations are currently under investigation.

Future investigations will focus on derivatization of phenols using a solvent effect to enhance the specificity of the reaction for these analytes. In addition apparatus will be tested which was designed both to simplify manual methods and as a prototype of robotic peripherals.

D17

PREPARATION OF HETEROCYCLIC PAH'S FOR ANALYTICAL STANDARDS.

E. Lee-Ruff* and F.J. Ablenas, Department of Chemistry, York University, Toronto, Ontario, M3J 1P3.

It is well known that polycyclic thiophenes and aza-PAH's are present in environmental samples. The characterization of these materials are based on spectral and chromatographic comparisons with reference standards. Whereas a number of well characterized carbocyclic PAH's is available, the availability of corresponding sulphur and nitrogen derivatives is limited. We have developed two general methods in the synthesis of PAH's incorporating non-benzenoid ring systems and have now extended these methods to the preparation of tetracyclic and pentacyclic thiophenes which are structurally related to known mutagenic carbocyclic PAH's. The details of these methods will be discussed and the synthesis of novel thiophene PAH's will be presented.

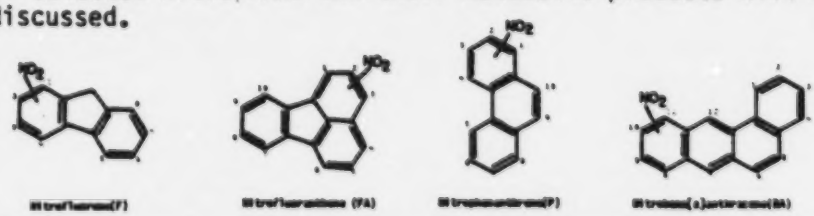
D18

PROVISION OF ISOMERICALLY PURE NITRO PAH ANNALYTICAL STANDARDS. Victor Snieckus, Guelph-Waterloo Centre for Graduate Work in Chemistry, University of Waterloo, Waterloo, Ontario N2L 3G1.

Since 1978, evidence has been accumulating that nitro polycyclic aromatic hydrocarbons (nitro-PAHs) are widely distributed in our environment and constitute potent direct acting mutagen in microbial test systems. Therefore, increasing attention has been devoted to their detection, identification, quantitation, and the elucidation of their atmospheric reactivity and biological activity. The evolution of the analytical and biological research on nitro-PAHs necessitates the availability of pure analytical standards. Currently available methods for the preparation of nitro-PAHs are based on classical (mainly electrophilic substitution) reactions which suffer from low yields, lack of isomer specificity, limited scope, and inefficiency.

The objectives of our study entail the provision of analytical standards of several classes of isomerically pure nitro-PAHs (nitrofluorenes, nitrofluoranthenes, nitrophenanthrenes, and nitrobenz[a]anthracenes) which are required for environmental research. The rationale for the targeted compounds is dictated by identification of certain nitro-PAHs in diesel exhaust and urban air particulate matter from Ontario and U.S. sources.

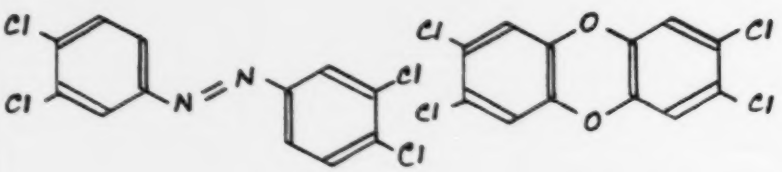
The application of synthetic methods recently discovered in our laboratories for the convenient preparation of nitrofluorenes, nitrofluoranthenes, and nitrophenanthrenes as single, analytically pure isomers will be presented. The general methodology and progress to date for the provision of selected nitro-PAHs and their metabolic products will be discussed.



DP1

SYNTHESIS OF CHLORINATED ANILINES. Nigel J. Bunce* and Mary E. Lemke, Department of Chemistry and Biochemistry, University of Guelph, Guelph, Ontario N1G 2W1, Canada.

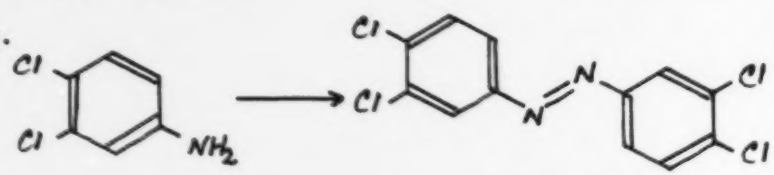
The toxic compound 3,3',4,4'-tetrachloroazobenzene (TCAB) has been found as a contaminant in certain commercial herbicide preparations. The azo compound is very persistent in the environment and has been recovered from soil samples treated with the subject herbicides. Of particular concern is the similarity in molecular shape and also toxicological properties of TCAB to the highly toxic 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD).



TCAB TCDD

In this project, reference samples of a series of symmetrically chlorinated azobenzenes were prepared by oxidation of the corresponding chloroanilines. A modification of a published procedure for oxidation was developed, in which silver carbonate on Celite was the oxidizing agent. Repeated chromatography was needed to obtain pure products.

e.g.



DP2

DUAL CAPILLARY COLUMN ANALYSIS OF PCBs IN DRINKING WATERS. P.W. Crozier* AND C.D. Hall, Ontario Ministry of the Environment, Laboratory Services Branch, Drinking Water Organics Section, Rexdale, Ontario.

Increased public awareness of the affects of chronic exposure to PCBs has sparked the need for fast accurate methods for quantitating PCBs in environmental samples. Original MOE quantitation methods involved solvent extraction followed by either perchlorination of all biphenyls to decachlorobiphenyl and its subsequent analysis or the quantitation and grouping of PCB peaks generated by single packed column GC analysis. The advent of capillary columns allowed for much greater resolution of individual PCB isomers and more accurate quantitation. Further enhancement of PCB quantitation techniques has been accomplished by using dual fused silica capillary column methodology for quantitation and confirmation of results.

Dual capillary column PCB quantitation methodology for the analysis of drinking water and drinking water sources was developed using PCB standards and fortified water samples. Results were obtained by quantitation against a 1:1 PCB mixture of Aroclors 1254 and 1260. The method was validated and checked against current MOE single packed column PCB methods using both laboratory standards and spikes as well as real environmental drinking water samples. Results obtained for both methods were comparable with the dual capillary column results being, on average, slightly higher.

DP3

A COMPARISON OF MASS SPECTRAL INSTRUMENTAL CAPABILITIES (LRMS, HRMS AND MS-MS) FOR CHLORINATED DIBENZO-P-DIOXIN AND DIBENZOFURAN DETERMINATION.

D. McCurvin*, R.E. Clement, V. Taguchi, E. Reiner and D. Schellenberg. Ministry of the Environment, Laboratory Services Branch, Drinking Water organics, 125 resources Road, Rexdale, Ontario.

Gas chromatography/Mass Spectrometry (GC-MS) systems are widely used for the analysis of Polychlorinated Dibenzo-p-dioxins and furans (CDD and CDF) in a variety of matrices. As a result many different GC-MS instrument types are in use for this type of analysis. Very little discussion has been carried out regarding the similarities or dissimilarities in CDD/CDF analysis using these instrument types.

We will discuss and compare high resolution MS, low resolution MS and MS-MS capability for CDD/CDF determination with respect to instrument detection limits, linear dynamic range, and analysis of real samples. Additional data comparisons of relative response factors of CDD/CDF, relative GC retention times and the stability of isotope/peak ratios will be made. With this type of comparative study, we will be able to define the degree of chemical workup and type of instrumentation needed for specific applications.

DP4

ICP/MS ISOTOPE RATIOS: Identification of Atmospheric Emissions of Metals

D. Bommer, F. Hopper, M. Powell, Ontario Ministry of the Environment.

Identification of the sources of pollutants is an important aspect of the work at M.O.E.

Very little work has been done on the use of isotopes for this purpose.

Pb is a good candidate for this study because it is known to be a widespread pollutant due to its use as an antiknock agent. Its isotopes can be detected at very low concentrations.

If the Pb isotope ratios in the minerals used to produced tetraethyl-Pb are characteristic of the geology and if the use of this Pb is regional then these facts could form the basis for tracing the origin of some forms of pollution.

We have performed concentration and isotope analysis on a 3 month set of daily air particulate samples taken from a remote site in Dorset Ontario. The data indicates that isotope ratios may be a valuable tool for determining the origin of pollution transported over long distances.

DP5

ICP/MS ANALYSIS OF DRINKING WATERS FOR 22 ELEMENTS AT SUB PARTS PER BILLION LEVELS

D. Boomer, R. Bennett, F. Hopper, Ontario Ministry of the Environment.

A method has been developed for the analysis of drinking water samples.

The concentrations of Cu Zn Sr Ba Mn B Al Fe Pb Ni Co Mo Ti V Cr U As Se Cd Be Sb Ag can be determined at lower levels and with a higher degree of reliability than with existing methods.

The method does not require preconcentration or separations.

Accuracy, precision, long and short term precision data will be presented.

DP6

THE APPLICATION OF SOLID PHASE EXTRACTION (SPE) TO THE ANALYSIS OF CHLOROPHENOLS AND PHENOXY-ACID HERBICIDES IN WATER. C.D. Hall* and B. Craig, Ontario Ministry of the Environment, Rexdale, Ontario and Paracel Laboratories Ltd.

The objective of this joint study was to determine the feasibility of using solid phase extraction for the analysis of chlorophenols and phenoxy-acid herbicides present in water. Although the GC analysis of these compounds is substantially automated the manual wet chemistry preparation is time consuming, labour intensive, and requires large volumes of expensive and toxic solvents. Solid phase extraction techniques are more suited to method downsizing and automation.

The study consisted of a literature review of current SPE technology followed by testing of various extraction parameters to optimize chlorophenol and phenoxy-acid herbicide recovery. Areas of investigation included individual company's SPE products, stationary phases, eluting solvents, component concentrations, component breakthrough volumes, water matrices and column plugging.

At least 100 mls of surface waters and somewhat greater volumes of well or treated water can be conveniently passed through the smallest SPE columns (100 mg).

All phases tested gave good recovery and reproducibility for the compounds of interest, particularly the J.T. Baker C18 column eluted with ethyl acetate containing 1% tetrahydrofuran. Chlorophenol and phenoxy-acid herbicide recoveries were generally reproducible over a range of concentrations and water matrices although dicamba and picloram recoveries were lower than other compounds. Recoveries were very dependent on the pH of the water.

DP7

DIOXINS AND FURANS IN TOXIC PRECIPITATION SAMPLES. C. Tashiro*(1), R. Clement(1), M. Lusis(2), D. Orr(2), N. Reid(2), 1. Laboratory Services Branch, Ontario Ministry of the Environment, Rexdale, Ontario. 2. Air Resources Branch, Ontario Ministry of the environment, Toronto, Ontario.

The long range transport of chlorinated dibenzodioxins (CDDs) and chlorinated dibenzofurans (CDFs) and their subsequent deposition via atmospheric precipitation is currently being studied. The presence of organic contaminants that are found in remote locations has been assumed to occur via long range transport, followed by deposition in precipitation.

Precipitation samples were collected at a remote location in Ontario for a four week period. Two sample collection methods are being investigated: (1) direct collection of precipitation in a custom-designed heated sampler and (2) percolation of the precipitation through an XAD-2 resin cartridge.

After collection, the samples were transported to the lab, solvent extracted, cleaned using column chromatography and analyzed by GC/MS for the presence of CDD/CDF. Both a field recovery spike and an extraction recovery spike are used to allow determination of percentage recoveries of CDD/CDF through analytical processing.

Initial results from a set of precipitation samples collected in a remote Ontario location indicated no 4CDD or 4CDF found at detection limits of 4 to 30 (ppq). Low ppq levels of 8CDD, 8CDF, 7CDD and 7CDF were detected.

Initial results from the remote Ontario location indicates that long range transport and deposition of airborne CDD/CDF do occur.

E1

UTILIZATION OF COTTAGERS' PERCEPTIONS IN ASSESSING THE PRESENCE AND IMPACT OF ALGAE ON ONTARIO RECREATIONAL LAKES. Keith Neuman*, Michael B. Jackson and K.H. Nicholls, Ontario Ministry of the Environment, Toronto, Ontario.

Based on recent evidence suggesting that the growth of two types of algae--Zygnema spp. (filamentous) and Chrysochromulina (odour-producing)--in Ontario softwater lakes may be the result of increasing acidification, the Ministry of the Environment conducted a study to obtain an accurate assessment of the incidence of these algae and their impact on lake recreational uses. Because the cost of conventional field surveys was prohibitive, an innovative approach was utilized which tapped the perceptions and first-hand experiences of lakefront cottage owners. A pilot study conducted on 10 lakes demonstrated that by using a multivariate predictive model, cottagers' perceptions could be used to accurately identify algae conditions on lakes. The main study produced data from a statistically representative sample of 4,400 cottagers on 214 lakes in central Ontario. Results indicate that filamentous algae are present in approximately 48% of lakes in the area, and odour-producing algae are present in about 6% of these lakes. A statistically significant positive relationship was observed between algal presence and lake acid sensitivity. Cottagers experiencing algae on their lakes expressed a high level of concern about algae and indicated that it has affected their general enjoyment and specific uses, such as swimming and boating. It is concluded that this type of social science research approach has potential applicability to the study of other environmental conditions.

E2

REGULATION AS A CAUSE OF POLLUTION REDUCTION: TWO CASE STUDIES. Donald N. Dewees*, Professor, Department of Economics, University of Toronto, Toronto, Ontario, M5S 1A1.

A recurrent theme in discussions of pollution control policy is the likely effectiveness of alternative policies. Environmental agencies across North America are often criticized for failing to achieve substantial improvements in environmental quality despite major programs and expenditures over the last two decades. This study examines two very different pollution problems in which government regulation played a role, but with very different outcomes. The discharge of mercury from chlor-alkali plants in Ontario was almost eliminated in a brief two year period. The events of this period are reviewed to examine the relative importance of government regulation, private litigation in Canada and the United States, public opinion, and other factors in achieving the dramatic reduction in discharge. A very different case is presented by sulphur oxide emissions which have been reduced gradually since 1970, but remain today at a substantial fraction of the 1970 levels. The events involved in reductions for the major sulphur oxide sources are reviewed. The reasons why one pollutant was controlled so decisively, and the other not are discussed.

E3

FINANCIAL ASSURANCE - A NEW TOOL FOR ENVIRONMENTAL PROTECTION, Jack A. Donnan*, M.B. Jackson and John Swaigen, Ontario Ministry of the Environment.

The recently enacted (Dec. 1986) Part X-A of the Environmental Protection Act gives the Ministry of the Environment the authority to require the deposit of financial assurance as a condition of an order or approval under the Environmental Protection Act or the Ontario Water Resources Act.

Implementation of Part X-A will provide funds for closure, clean-up and rehabilitation of sites whose owners go bankrupt or abandon them. Financial assurance will also provide an hitherto non-existent economic incentive to complete programs on time and it should curtail the use of financial hardship as an excuse for missing deadlines.

Prior research and administrative activities which contributed to the development of the legislation will be recounted in this paper.

The potential costs to regulated parties of financial assurance are the additional interest, over and above government rates, which cash deposits could otherwise earn; reductions in available cash flow, service charges of letters of credit ($5-$10 per $1,000 per year), "premiums" on surety bonds ($15 per $1,000 per year) and the loss of liquidity of a transferable bond.

To date, financial assurance has been provided primarily by owners of private waste disposal sites.

Guidelines for the application of financial assurance to other types of approvals and orders have been prepared.

Approvals and orders for which financial assurance is designated as discretionary and those which are mandatory are identified. Procedures for estimating the value of required assurance for mining operations, industrial abatement programs and waste disposal sites are described.

Finally, a number of questions and issues which require further research are identified.

E4

DISPOSAL OF FORMATION FLUIDS BY OIL PRODUCERS IN PETROLIA, ONTARIO - A SOCIO-ECONOMIC ASSESSMENT. Michael Goodchild,* Department of Geography, University of Western Ontario, London, Ontario and Jack A. Donnan, Ontario Ministry of the Environment, Toronto.

Oil wells in southwestern Ontario produce large amounts of mildly salty water (called "formation fluids" or "brine" although it is only 1/3 as salty as sea water) along with the oil. This brine contains chlorides, hydrogen sulphides and small amounts of residual hydrocarbons which can impair the quality of receiving water courses. Traditionally, formation fluids have been disposed of by evaporation or by discharge into surface watercourses. This practice is environmentally undesireable. More acceptable technologies have been investigated by government officials and oil producers who determined that the deep-well injection into the porous Detroit River Formation below the oil bearing strata is the preferred disposal method.

The costs of implementing 5 deep-well disposal program options were estimated using a location-allocation model modified specifically for this problem. These options ranged from the installation of disposal wells at each producer site to various combinations of centralized disposal wells with pipeline or truck transportation modes.

The model was used to determine the combination of transportation modes (truck or pipeline) and locations of disposal wells that would be least-cost. For a given set of input data, the least-cost program was the installation of two centralized disposal well facilities at producer locations who already have one disposal well in place.

Since oil producers have no experience with the installation or operation of pipelines to centralized disposal facilities, the cost estimates are uncertain. The model was used to conduct sensitivity analyses of some of the uncertain parameters. Policy implications are also discussed.

E5

BEACHES IN LOTUS: A MICROCOMPUTER MODEL OF SPATIAL RECREATION BEHAVIOUR.

Jack B. Ellis*, Professor in Environmental Studies, York University, Toronto

The search for a tool to understand shifts in the use of beaches in Ontario resulted in a two-stage gravity-based model being implemented on a microcomputer using the popular spreadsheet software, Lotus 123. The model draws on a database containing information on over 600 of the major beach locations in Ontario. It is structured to represent 11 origin zones and 13 destination zones at its inter-regional stage. At the intra-regional stage, it allocates beach use to each of over 500 separate locations.

The model is based on demographically-sensitive participation rates in swimming, and uses separate matrices for home-based and non-home based participation. It is sensitive to environmental and esthetic factors, and reflects instantly the effects of beach closures by reason of water pollution. It has been designed for future incorporation of economic valuation parameters, as well as for ease of use and quick updating by non-specialized personnel.

E6

THE TRANSPORTATION OF LIQUID INDUSTRIAL WASTE IN ONTARIO, Arthur Donner, Norman Mogil* and Ron Thompson, A.R.A. Consultants Ltd., Toronto.

This study describes the economic, financial and structural characteristics of the liquid waste haulage industry in the province. The data sources include Statistics Canada, government reports, trade journals and interviews with selected industry representatives and operators. "Liquid industrial waste" includes all liquids which are subject to Regulation 309, including hazardous liquid wastes.

Approximately, 90% of all revenues were derived from routes in excess of 25 km within the province. The average firm has total fixed assets of $1.4 million, shareholder's equity of less than $500,000, and a debt/equity ratio of 3.8, suggesting the industry is small, under-capitalized with a high debt load.

Southwestern Ontario accounts for 40% of all tonnage shipped with the Hamilton-Niagara area accounting for an additional 29%. Average tonnage per firm in the province was 8,971 per year. For the province as a whole, the three largest firms account for 29% of all tonnage and 17% of all shipments.

The transportation of liquid industrial waste is extremely competitive on the basis of price. The price varies due to three key factors: type of materials handled; distance traveled; and nature of the equipment required.

Several of the smaller firms are merging or have been bought out in the wake of a general rationalization taking place in transportation and trucking in particular. There is a movement towards greater vertical integration into "downstream" operations, i.e., disposal sites.

EP1 THE EFFECTS OF FORESTRY OPERATIONS UPON THE ENVIRONMENT OF ONTARIO. Julian Dunster,* Federation of Ontario Naturalists, Don Mills, Ontario.

A large amount of detailed information about specific aspects of forestry exists. However, it is becoming increasingly apparent that the effects of forestry operations upon the environment of Ontario are complex, and the linkages between the physical, economic and sociocultural environment are not being clearly identified, or are poorly understood. The detail available on specific environmental effects is variable in quality, quantity, and relevance to the present day situation.

The research underway concentrates on the environmental effects of the "stump to dump" phase of forestry operations (i.e. harvesting, regeneration and silviculture, and delivery of the wood to the mill). The research hopes to establish and assess :

- the extent and relevance of the literature, concepts and practices, pertaining to the environmental effects of forestry, focussing in particular on:
  - ecosystem dynamics
  - chemicals in forestry operations
  - economic ramifications
  - environmental progress.
- the physical, economic and social cause and effect linkages.

The product of this research will highlight the strengths and weaknesses of the current knowledge about the environmental effects and the cause and effect linkages. It will also provide a framework of information against which future research, management and planning needs can be judged. From this foundation, solutions and recommendations will be developed. The format of this final report will be similar in concept to a 'State of the Environment' report; a reporting format that although relatively new in Canada, has already demonstrated potential to facilitate decision making by resource managers and the general public. Preliminary results are expected in the Spring of 1988.

EP2 BIOTECHNOLOGY POLICY DEVELOPMENT. The Canadian Environmental Law Research Foundation, 243 Queen Street West, Toronto, Ontario.

This consultative research project, funded by the Ontario Ministry of the Environment, was intended to assist the Ontario government in development of regulatory policy governing release of genetically altered organisms to the open environment. Two background papers were prepared and each was discussed in the fall of 1986 at one-day seminars attended by revelant Canadian authorities. The first paper, authored by Dr. Bernard Glick, University of Waterloo, set forth potential environmental impacts of biotechnology releases. The second, authored by Ms. Irene Courage, LLB, set forth policy issues, such as federal-provincial jurisdiction or potential application of existing legislation, which must be considered during biotechnology policy development.

The study recommends that a distinction be made between initial experimentation releases and ongoing commercial application. It is recommended that MOE be the approval agency for all experimental releases in the province and that this be done by means of the Ontario Environmental Assessment Act, while steps are taken in concert with other agencies to develop a permanent national, regulatory mechanism.